PARKING NEEDS AND SITE EVALUATION STUDY

New England Medical Center Hospitals
Boston, Massachusetts

Vanasse/Hangen

PARKING NEEDS AND SITE EVALUATION STUDY

prepared for

NEW ENGLAND MEDICAL CENTER HOSPITALS, INC.
BOSTON, MASSACHUSETTS

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prepared by

VANASSE/HANGEN
Transportation Engineers & Planners
60 Birmingham Parkway
Boston, MA 02135

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ASSESSMENT OF PARKING AND TRANSPORTATION CONDITIONS

SECTION I

ASSESSMENT OF PARKING AND TRANSPORTATION CONDITIONS

Phase I of the study effort consisted of the collection and analysis of data pertaining to background transportation characteristics. The information assembled was used to assess current and future parking needs, and provide a baseline against which the impacts of new parking facilities and transportation service improvements could be determined. The following areas of analysis formed the focus of this phase of study:

- Parking conditions, now and in the planning horizon year of 1990.
- Current and projected year 1990 traffic conditions.
- Characteristics of transportation services provided to the NEMCH community.
- Travel characteristics of the NEMCH community.

This section of the report presents the results of the data collection and analysis tasks performed in Phase I of the study.

A. EXISTING CONDITIONS

1. Parking

A key objective of the study was to assess current parking needs through the analysis of hospital-generated demand in relation to the existing study area parking supply. Parking data

were collected from hospital sources and through the following field surveys:

- Supply inventory - April 3, 1985.
- Off-street parking accumulation count - April 3, 1986.
- Questionnaire survey of hospital users - May 1, 1986.
- Peak period on-street parking accumulation count - May 20, 1986.

The analysis results are discussed below.

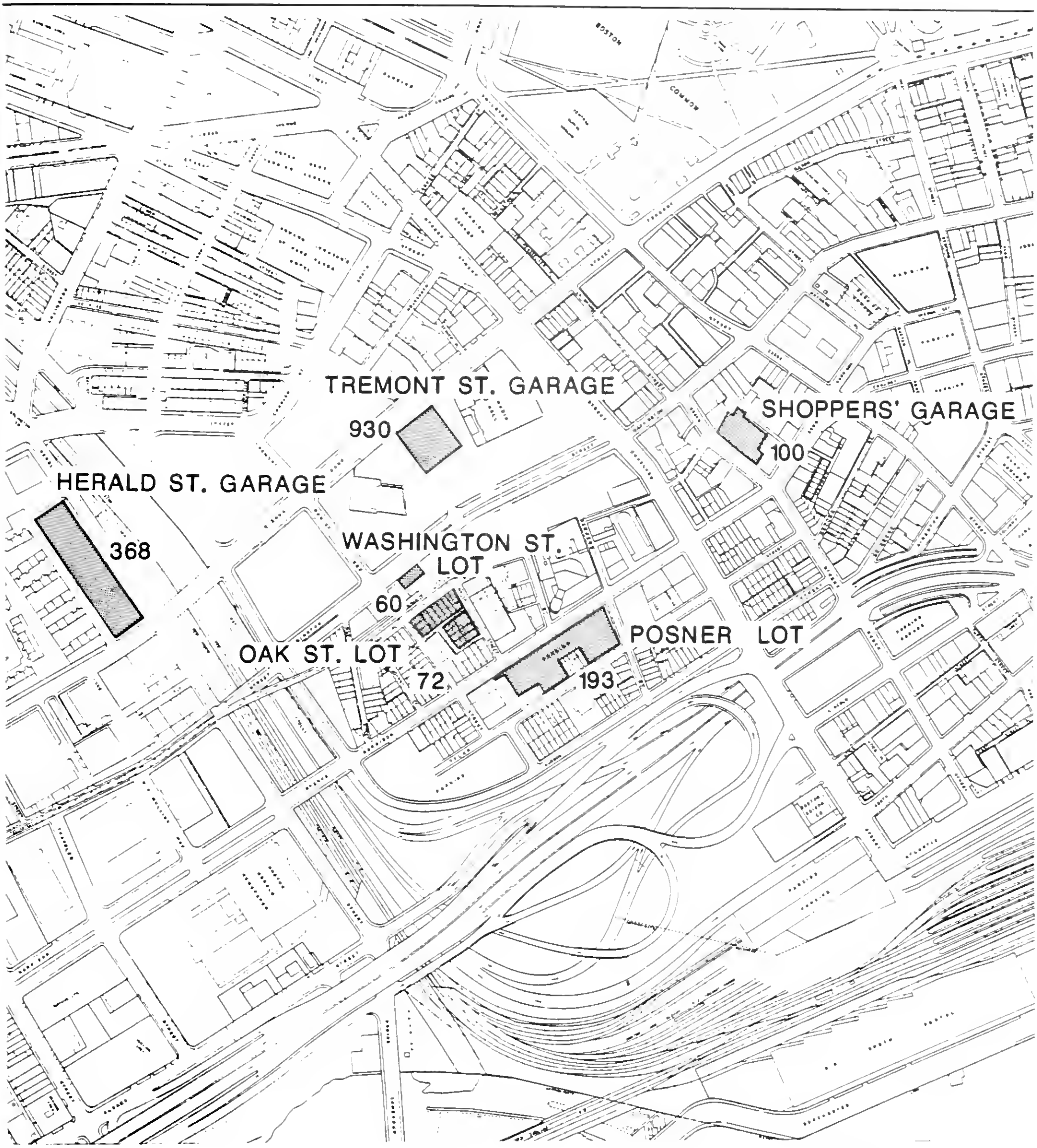
- NEMCH Supply Inventory

NEMCH currently utilizes parking spaces in six off-street facilities. Table 1 shows the number of spaces provided for hospital users and the user designation at each facility. The numbers shown in the table represent spaces counted during Vanasse/Hangen's supply inventory. The VH count differs slightly from the hospital's official space tally, as follows. The hospital's records show 400 spaces at the Herald Street Garage versus 368 counted by VH. The difference reflects the fact that 32 striped spaces in the garage are actually unusable due to structural deficiencies. In addition, VH counted 14 more spaces at the Oak Street Lot than does the hospital, and at the Washington Street Lot, an additional six spaces. In total, VH counted 12 fewer spaces than did the hospital. The total off-street hospital parking supply, as inventoried by Vanasse/Hangen, is 1,723 spaces.

TABLE 1
PARKING SUPPLY

	Supply	User Designation
Posner Lot	193 spaces	Employees, patients and visitors
Herald Street Garage	368 spaces	Employees, Tufts students
Tremont Street Garage	930 spaces	Employees, patients and visitors
Oak Street Lot	72 spaces	Employees
Washington Street Lot	60 spaces	Employees (2nd shift)
Shopper's Garage	100 spaces	Employees
Total	1,723 spaces	

It is important to note that of the hospital's total parking supply, only 1,100 spaces (65 percent) are owned by Tufts University/NEMCH. The remaining 600 spaces are rented under two to three-year leases and cannot be counted as being available to the hospital on a permanent basis. The facilities owned predominantly or completely by Tufts/NEMCH are the Tremont Street Garage, Oak Street Lot, and the Posner Lot. These are all located within the primary area of NEMCH development bounded by Kneeland Street/Stuart Street on the north, Harrison Avenue on the east, Oak Street on the south and Tremont Street on the west. The Herald Street Garage, at which the hospital leases 400 spaces (368 of which are functional), is located to the south of the Massachusetts Turnpike, about 1/4-mile walking distance from the central area of the hospital, and is served by a NEMCH-sponsored shuttle bus. The hospital also leases 100 spaces at the Shopper's Garage on Beach Street, approximately 1,000 feet from the central hospital area (i.e., the Floating hospital and the Proger Building on Washington Street). The locations of all NEMCH off-street parking facilities are shown in Figure 2.



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Off-Street Parking Supply

368
102

Fig. 2

• On-Street

On-street parking is provided throughout most of the study area. The major streets which traverse the immediate hospital area provide a total of approximately 210 legal curbside space, most of these being metered. Twenty of these spaces are reserved for resident permit parking only. The distribution of on-street spaces by street segment is shown in Table 2.

TABLE 2
ON-STREET PARKING SUPPLY IN THE
IMMEDIATE HOSPITAL VICINITY

Street Segment	Legal On-street Spaces
Washington Street	
Kneeland-Oak (W)	27
Kneeland-Oak (E)	36
Oak-Marginal (W)	8
Oak-Marginal (E)	11
Kneeland Street (S)	
Tremont-Washington	16
Washington-Harrison	12
Harrison Street	
Kneeland-Harvard (W)	12
Kneeland-Harvard (E)	14
Harvard-Oak (W)	13
Harvard-Oak (E)	9
Oak-Marginal (W)	12
Oak-Marginal (E)	10
Oak Street (S)	
Washington-Harrison (S)	12 *RPP
Tremont-Washington (S)	8 *RPP
Nassau (N)	12
Total	

* RPP = resident permit parking

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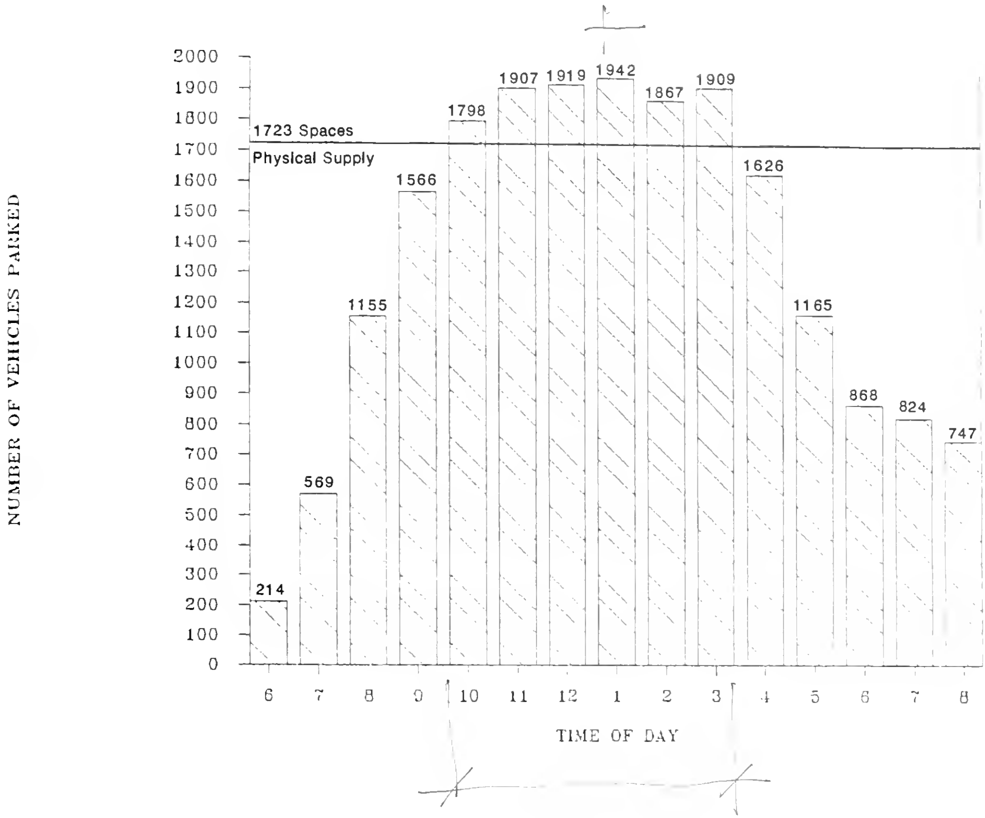
The fee schedule for all six parking facilities at the time of the surveys and proposed changes are shown in Table 4. Employees pay $3.00 to $3.25 per day at all facilities except the herald street garage, where daily fees are $2.00 to $2.50 per day. Monthly assigned parkers are charged $.25 to $.75 more per day than daily employee parkers. Patients and visitors, who are limited to the posner lot and Tremont Street Garage, pay higher rates on an hourly basis than do employees. The rate schedule for both these facilities is the same. The fee for the first hour is $1.50, and the maximum fee for 4.5 hours or more is $5.00. Fee structure changes for employees are scheduled to be implemented in August of this year. In general, these changes will increase daily employee parking fees to the following levels:

- on-campus garage - $4.00
- on-campus lots - $3.50
- off-campus garages - $3.00

• Accumulation

Vanasse/Hangen conducted a 100 percent count of vehicles parked in the hospital's parking facilities, on Thursday, April 3, 1986, selected as a typical weekday. Hospital census data indicate that in 1985, the month of April was average in terms of outpatient and emergency room visits, patient days and admissions. The second quarter of the year, beginning in April, showed slightly higher outpatient and emergency room visits than other quarters of the year, although month-to-month variations exceeded the relatively small seasonal differences. The count provided data on parking accumulation at hourly intervals from 6:00 AM through 8:00 PM. The pattern of accumulation over the course of the day is illustrated in Figure 3. The figure shows rapidly climbing accumulation from 6:00 AM through 10:00 AM, at which point approximately 1,800 vehicles are parked in hospital

1723
210
1923



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60 Birmingham Parkway Boston MA 02135

Parking Accumulation

Fig. 3

TABLE 4
EXISTING PARKING RATES

Facility	User	Time in Lot	Parking Rate As of June 1986	Parking Rate As of August 1986
Posner Lot	Patients/	.50 hr.	$ .75	$ .75
	Visitors	1.00 hr.	$1.50	$1.50
		1.50 hr.	$2.00	$2.25
		2.00 hr.	$2.50	$3.00
		2.50 hr.	$3.00	$3.75
		3.00 hr.	$3.50	$4.50
		3.50 hr.	$4.00	$5.25
		4.00 hr.	$4.50	$6.00
		4.50 hr.	$5.00	$6.75
		>4.5 hr.	$5.00	$7.00
	M-Club	All Day	$3.00	$3.50
	Daily's	All Day	$3.00	$3.50
	Monthly's	All Day	$3.25	$3.75
Herald St. Garage	Students	All Day	$2.00	$2.50
	Employees	All Day	$2.50	$3.00
Oak Street Lot	Daily's	All Day	$3.00	$3.50
	Monthly's	All Day	$3.25	$3.75
Tremont St. Garage	Patients/	.50 hr.	$ .75	$ .75
	Visitors	1.00 hr.	$1.50	$1.50
		1.50 hr.	$2.00	$2.25
		2.00 hr.	$2.50	$3.00
		2.50 hr.	$3.00	$3.75
		3.00 hr.	$3.50	$4.50
		3.50 hr.	$4.00	$5.25
		4.00 hr.	$4.00	$6.00
		4.50 hr.+	$5.00	$6.75
		>4.5 hr.	--	$7.00
	M-Club	All Day	$3.00	$4.00
	Daily's	All Day	$3.00	$4.00
	Monthly's	All Day	$3.75	$4.75
Washington St. Lot	Daily's	All Day	$3.00	$3.50
Shopper's Garage	Monthly's	All Day	$3.00	$3.00

facilities. Demand peaks at 1:00 PM when parking accumulation in hospital facilities reaches 1,942 vehicles, which represent 219 vehicles more than "physical" capacity. Occupancy levels remain at roughly this level through 3:00 PM. Between 3:00 and 5:00 PM there is a substantial hourly decline in accumulation as day-shift employees leave work. Between 6:00 and 8:00 PM, accumulation continues to decrease, although at a more gradual rate. At 7:00 PM, there are approximately 750 vehicles in hospital parking facilities.

Hospital records show that on a typical weekday, approximately 2,450 vehicles park in its facilities over the course of the day. Of these, it is estimated that approximately 1,500 are driven by hospital employees, based on sticker revenue information. Based on turnover rate per space of 1.3 vehicles per day, the hospital has calculated its peak utilization at 1,942 spaces, independently of the VH analysis.

Table 5 presents information on peak hour parking accumulation by facility. The table shows that the peak hour for individual facilities differs slightly from that of the systemwide peak. Whereas the system peaks at 1:00 PM, only the Posner Lot shows a peak at that hour. Posner also has a peak at 11:00 AM, as do the Herald Street Garage and Shopper's Garage. Accumulation at the Oak Street Lot peaks at 12:00 noon. The Tremont Street Garage peak is at 3:00 PM, while the occupancy of the Washington Street Lot remains constant at peak levels from 4:00 PM through 8:00 PM. At the system peak of 1:00, occupancy of the Posner Lot, Herald Street and Tremont Street Garages, and Oak Street Lot exceeds physical capacity, and the Shopper's Garage is used at 95 percent of its physical capacity. Only the 60-space Washington Street Lot, which is used primarily for second shift nurses, has capacity available at 1:00 PM. All of the six facilities are operated substantially over capacity during their individual peak hours. In general, with the exception of the

Washington Street lot, the NEMCH parking facilities are used at their capacity or in excess thereof throughout much of the day.

TABLE 5
PEAK HOUR PARKING ACCUMULATION

Facility	Supply	Hospital Peak Hour (1:00 PM)	Individual Facility Peak Hours	
Posner Lot	193	217	217	11:00 AM and 1:00 PM
Herald St. Garage	368	490	499	11:00 AM
Tremont St. Garage	930	1,026	1,029	3:00 PM
Oak Street Lot	72	91	98	12:00 Noon
Washington St. Lot	60	23	65	4:00 PM to 8:00 PM
Shopper's Garage	100	95	98	11:00 AM and 12:00 Noon
Systemwide Total	1,723	1,942	--	1:00

Parking accumulation counts were also conducted from 11:00 AM through 3:00 PM at on-street spaces in the central part of the study area, shown in Figure 4. These counts show the available 210-space supply of on-street spaces being used at 98 to 100 percent of physical capacity from 11:00 AM through 2:00 PM. At 3:00 PM, the occupancy rate of on-street spaces drops to 90 percent.

11:00 - 2:00 pm.

• Comparison of Parking Supply and Demand

As noted above, the observed parking accumulation in hospital-controlled off-street facilities at the peak hour of 1:00 PM is 1,942 vehicles, which exceeds the available physical off-street supply of 1,723 spaces by 219 spaces. However, the simple comparison of observed off-street demand and physical

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supply does not fully represent the magnitude of peak hour parking shortages. Several factors must be considered to provide a more complete view of both supply and demand.

With regard to parking supply, the actual number of available physical parking spaces is often a misleading indication of a system's true practical capacity. If a parking facility is to operate efficiently, its occupancy level must be below 100 percent to allow drivers entering the facility to find available spaces without excessive delay or inconvenience. As the occupancy of a parking facility approaches 100 percent, illegal parking and circling or "cruising" within the facility by drivers searching for spaces become more frequent. In the case of the NEMCH, the cruising largely takes place on the surrounding street network. Some studies have shown that "cruising" traffic can represent anywhere from 30 to 70 percent of the roadway volume in an urbanized area.

Typically, the practical capacity of a parking facility is considered to be 85 to 90 percent of its physical capacity. In general, public on-street supply approaches its practical capacity at 85 percent. At employee parking facilities, where parking space turnover is low and users park on a regular basis, users tend to be adept at finding available spaces, and practical capacity is about 95 percent. In addition, the attendant park system used at the Posner Lot for visitors results in high utilization of available space. As a result, it was assumed that using a 95 percent practical capacity factor would more appropriately reflect conditions at NEMCH. Applying a 95 percent adjustment factor, the practical capacity of NEMCH-controlled parking facilities is 1,637 spaces. Comparing this figure to observed accumulation at NEMCH-controlled facilities yields a peak period supply deficit of 305 spaces.

Another factor which should be considered is the use of on-street spaces by NEMCH-related parkers. The on-street accumulation counts showed occupancy rates of or near 100 percent from the period from 11:00 AM through 3:00 PM. A survey conducted in conjunction with this study and reported later in this section also showed that approximately 13 percent of those that drive to the hospital park on-street. Assuming this percentage holds in the peak period, it is estimated that there are 220 hospital-related vehicles parked on-street at 1:00 PM. If these vehicles are taken into account, total NEMCH-related peak period parking demand rises to 2,162 spaces when on-street demand is added to the NEMCH-controlled off-street facility data, the supply deficit rises to 439 spaces relative to total off-street capacity, and 525 spaces relative to practical off-street capacity. When only the hospital's permanent supply is considered and leased spaces are omitted, the supply deficit increases to 1,069 spaces relative to practical capacity. Table 6 summarizes the comparison of demand versus supply.

These figures indicate a definite need for expansion of the hospital's parking supply, from a minimum of 229 spaces to as many as 1,069 spaces. The minimum supply increase of 229 spaces does not allow for practical capacity considerations and is based on continued use of more than 200 on-street spaces during the peak hour by NEMCH parkers as well as 573 leased spaces. Taking into account a 95 percent practical capacity factor, and excluding on-street spaces, the hospital's current parking need is 525 spaces. Finally, projecting the possible loss of currently-leased spaces, NEMCH would require over 1,000 additional spaces, above its existing off-street supply, to fully accommodate its parking needs.

85 | 525

5.5

95 | 525

475

500

1723
210
1933

attendant Park System

TABLE 6
COMPARISON OF PEAK PERIOD
SUPPLY AND DEMAND

	Number of Spaces
NEMCH Parking Demand	
Off-Street	1,942
On-Street	220
Total	2,162
Supply	
Off-Street	
NEMCH-owned	1,150
NEMCH-leased	573
Total Physical	1,723
Total Practical	1,637
On-Street	
Total Physical	210
Total Practical	(0.85) 179
Total Supply (on- and off-street)	
Physical Capacity	1,933
Practical Capacity	1,816
Surplus/(Deficit)	
In terms of:	
Total Physical Supply	(229)
Total Practical Supply	(346)
Off-Street Supply Only (Practical)	(525)
Less Leased Space (Shopper's and Herald Street)	(1,069)

2162
573
1689

2162 525 95%

2. Traffic Conditions

Existing traffic conditions in the study area were examined as a basis for determining the incremental traffic impacts associated with alternative parking garage sites. This evaluation consisted of the following techniques:

- analysis of traffic volumes in relation to the function and character of individual links in the roadway network, and

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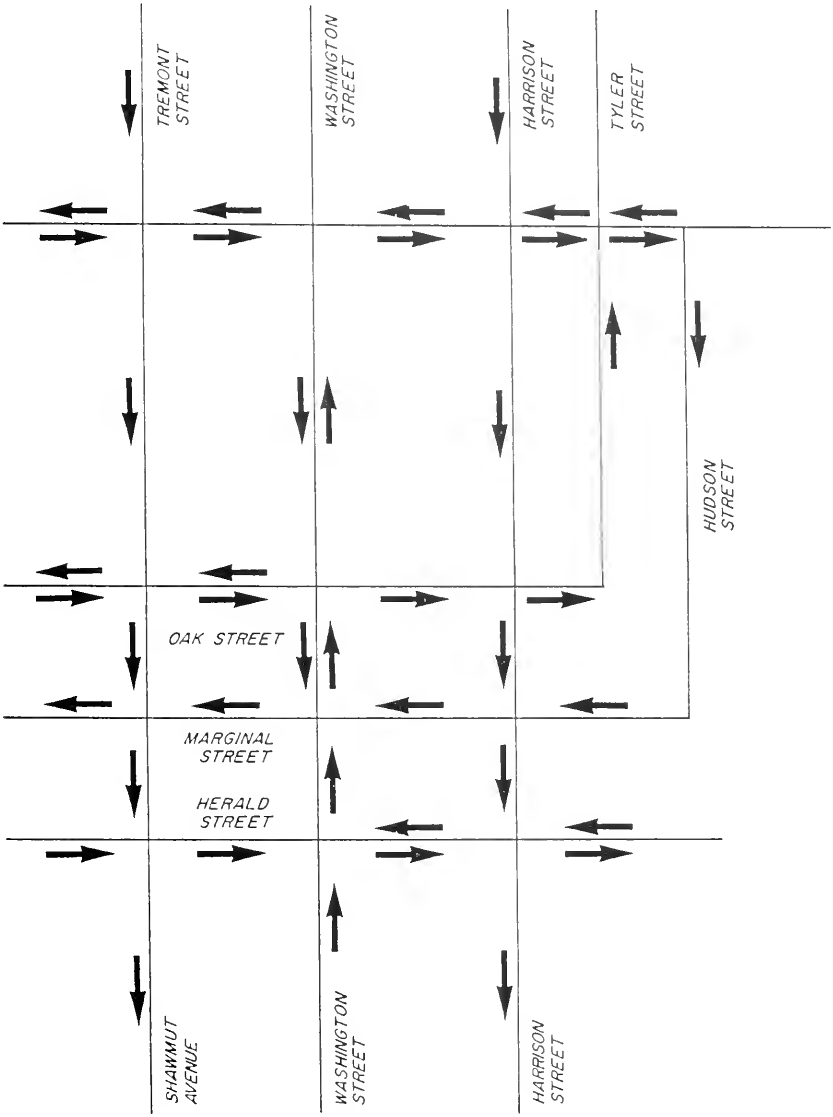
- traffic flow analysis, in terms of level of service at study area intersections.

These techniques and their results are presented in this section following an overview of the traffic network.

- <u>Network</u>

The street system in the study area is illustrated in Figure 5. The study area is served directly by the two major limited access highways entering Downtown Boston: I-90, the Massachusetts Turnpike Extension, and I-93, the Central Artery/ Southeast Expressway. The Massachusetts Turnpike Extension crosses the study area below grade in an east-west direction, and I-93, which operates in a north-south direction, and actually forms the eastern boundary of the study area. These highways provide vehicle access to the Tufts-NEMCH complex from virtually the entire Boston metropolitan region. Access/egress to these facilities are located approximately 1/4-mile from the central area of NEMCH.

Crossing the study area are several urban arterial roadways which primarily serve through movements between areas and across the City, as well as providing the connection between NEMCH and the regional highway system. These roadways are as follows: Kneeland Street/Stuart Street (east-west), Tremont Street (north-south), Herald Street (east; east-west in vicinity of I-93), and Marginal Street. Travel between the study area and I-90/I-93 is via Kneeland Street/Stuart Street, which borders the Tufts/NEMCH complex on the north, and Herald Street to the south of the complex. Washington Street and Harrison Avenue are primarily collector streets serving traffic movement between the arterials and local streets. Oak, Tyler, Hudson and several smaller roadways are local study area streets.



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60 Birmingham Parkway Boston MA 02135

Directional Traffic Network

Fig. 5

Two-way streets and street segments in the study area are Kneeland Street/Stuart Street, Washington Street between Kneeland and Marginal Streets (north-south), Herald Street to the east of Washington Street (east-west), and Oak Street (east-west) to the west of Washington Street. All other roadways in the study area provide only for one-way traffic flow, as indicated in Figure 5.

- Traffic Volumes

Morning and evening peak hour traffic volume data for the study area are shown in Figures 6 and 7. The figures shown represent the number of vehicles counted during the morning and evening peak commuter traffic hours, generally 8:00 to 9:00 AM, and 4:30 to 5:30 or 5:00 to 6:00 PM. These data were drawn from manual turning movement counts conducted by Vanasse/Hangen at 13 key intersections in the study area from 7:30 to 9:30 AM, and 4:00 to 6:00 PM. These counts were conducted over a 3-1/2 week period extending from March 27 to April 23. The schedule of counts and actual count data are presented in the Appendix A.

The data show the largest hourly traffic volumes by street segment to be as follows:

AM	Number of Vehicles[1]
• Kneeland between Washington and Harrison	815 (WB) 655 (EB)
• Marginal between Washington and Shawmut	1,195 (WB)
• Washington between Herald and Marginal	1,645 (NB)
• Herald between Harrison and Washington	834 (WB) 655 (EB)
• Tremont between Stuart and Oak	720 (SB)

====================

1/ Volumes shown represent maximum on roadway segment.

Existing A.M. Peak Hour Traffic Volumes

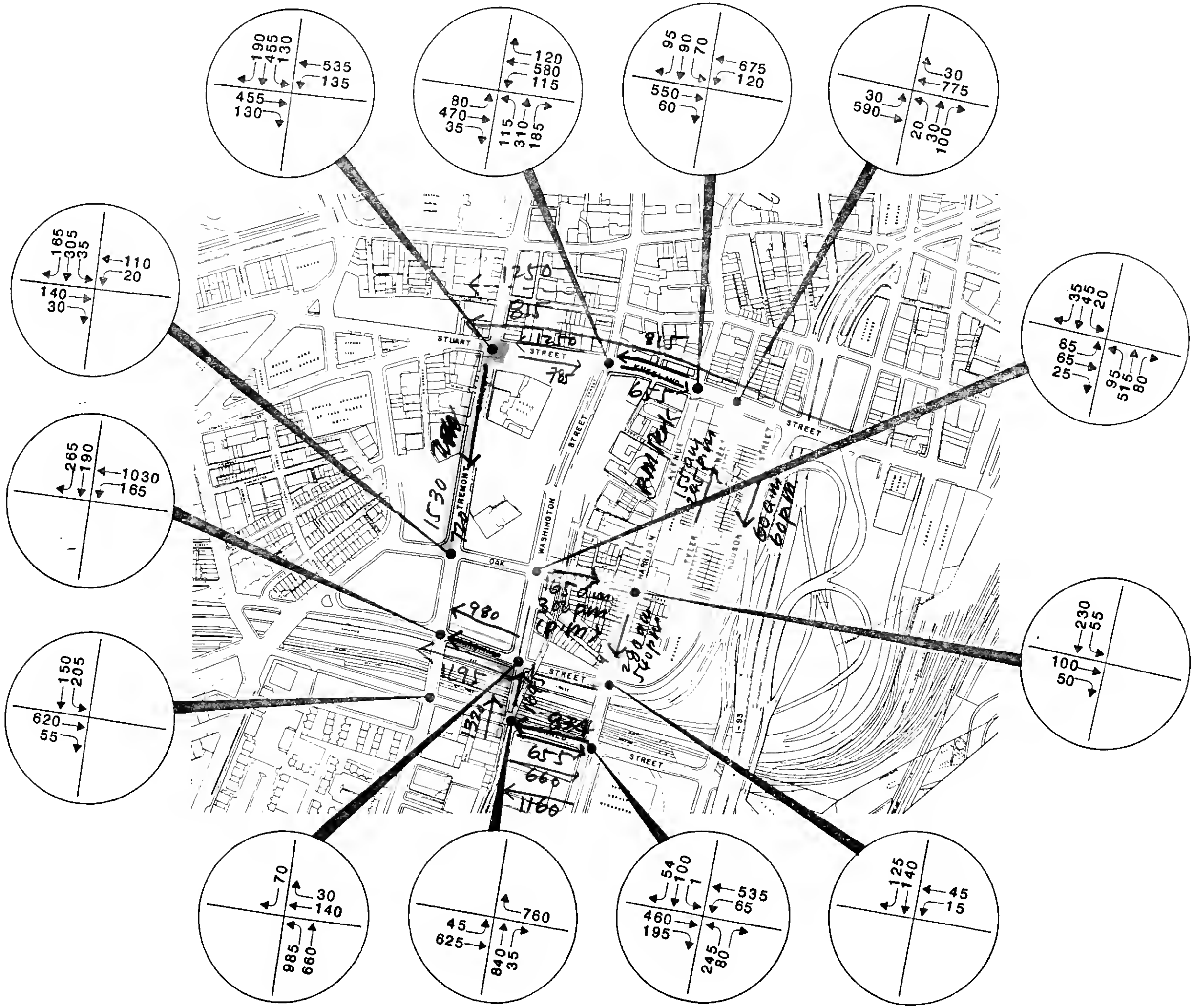

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Fig. 6

Existing P.M. Peak Hour Traffic Volumes

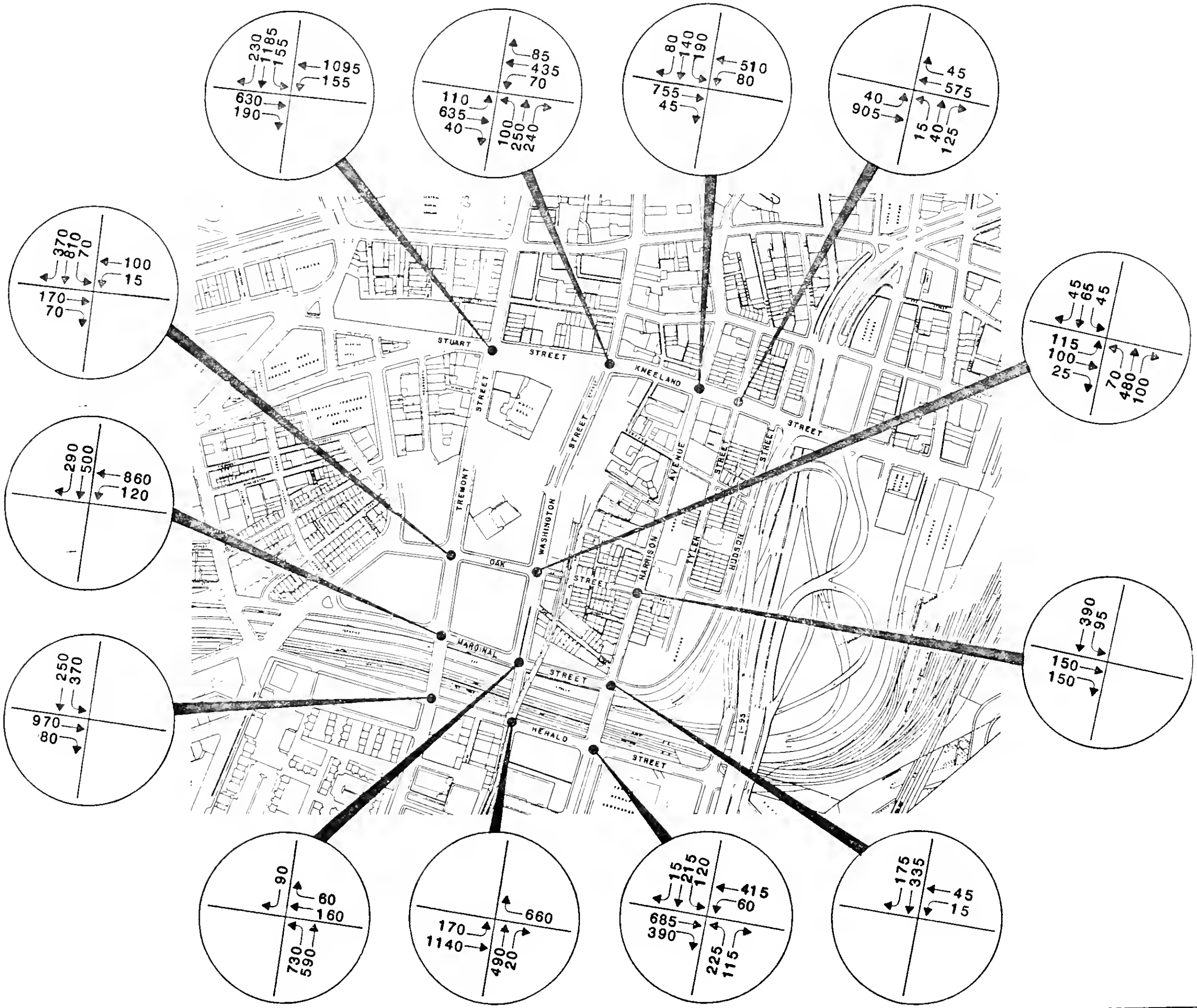

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Fig. 7

PM	Number of Vehicles
• Stuart between Tremont and Washington	1,250 (WB) 785 (EB)
• Marginal between Shawmut and Washington	980 (WB)
• Washington between Herald and Marginal	1,320 (NB)
• Herald between Washington and Harrison	660 (EB) 1,160 (WB)
• Tremont between Stuart and Oak	1,530 (SB)

Several of the local streets carry substantially smaller traffic volumes. Nevertheless, these streets tend to be more sensitive to the impacts of traffic because of the residential character of adjoining land uses. Morning and evening hourly traffic volumes on selected local street segments are as follows:

	AM	PM
• Oak between Washington and Harrison	165	300
• Harrison between Oak and Marginal	280	540
• Hudson	60	60
• Tyler	155	245

In addition to the morning and evening intersection counts which served as the source of the above data, 24-hour mechanical counts were recorded at a number of key mid-block locations in the study area. The data obtained from these counts are summarized in Table 7. The table shows the pattern of traffic volume fluctuations over the course of the day at each counting location. Peak volumes tend to coincide closely with the typical peak commuter periods on most study area streets. Additional noteworthy characteristics of the data shown are as follows:

- On Harrison Avenue (north of Bennet Street), the AM peak hour occurs from 10:00 to 11:00, which is after the commuter peak ending at 9:30. Midday traffic, from 12 Noon

TABLE 7
24-HOUR TRAFFIC COUNTS

Time of Day	Kneeland - EB/WB* (E. of Hudson)	Harrison - SB** (N. of Bennet)	Oak - EB*** (E. of Washington)	Tremont - SB+ (S. of Stuart)	Bennet - WB++ (W. of Harrison)	Marginal - WB+++ (W. of Harrison)
AM						
12-1	517	132	32	548	3	92
1-2	502	107	42	437	4	84
2-3	358	80	27	490	2	95
3-4	295	48	17	270	0	112
4-5	276	41	13	203	3	52
5-6	649	65	14	221	5	33
6-7	1,097	137	76	491	31	34
7-8	1,338	241	133	592	31	55
8-9	1,377	325	182	679	37	145
9-10	1,040	368	137	699	41	168
10-11	1,262	422	142	678	53	139
11-12	1,178	329	145	659	47	179
PM						
12-1	1,275	419	102	728	70	176
1-2	1,248	423	111	770	63	189
2-3	1,369	384	171	815	48	223
3-4	1,341	388	229	853	32	215
4-5	1,401	358	227	957	33	204
5-6	1,393	413	182	1,096	25	240
6-7	1,204	305	108	807	29	246
7-8	1,051	234	76	832	19	187
8-9	1,044	239	83	727	10	181
9-10	913	189	69	741	4	159
10-11	888	229	59	760	27	164
11-12	689	194	62	634	19	146
Total	23,705	6,070	2,439	15,687	636	3,518

* Average of Monday, Tuesday, and Thursday counts.
** Average of Tuesday, Wednesday and Thursday counts.
*** Average of Monday and Tuesday counts.
+ Average of Tuesday, Wednesday and Thursday counts.
++ Average of Tuesday, Wednesday and Thursday counts.
+++ Average of Monday and Friday.

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to 2:00 PM, is comparable to the 420-vehicle volume recorded from 10:00 to 11:00 AM. Volumes in the last hour of the AM commuter peak period are likely to be on the order of 70 vehicles less, or 350 vehicles in total. Volumes during the PM peak hour, however, recorded as 413 vehicles, are among the highest observed throughout the day.

- On Bennet Street, the highest volumes for the day were recorded from 12 Noon to 1:00 PM. During this hour, 70 vehicles were counted. This volume is only 29 vehicles higher, however, than the peak AM commuter count of 41 vehicles which occurred between 9:00 and 10:00 AM.

- While peak traffic periods coincide with commuter hours on Kneeland Street, volumes exceed 1,000 vehicles per hour between 6:00 AM and 9:00 AM. After 12:00 noon, traffic volumes build to the peak of 1,401 vehicles from 3:00 to 4:00 PM.

- On Oak Street, volumes during the PM peak period, which extends from 3:00 to 5:00 PM, are more than 20 percent higher than volumes during the AM peak hour of 8:00 to 9:00 AM.

- Traffic volumes build on Tremont Street throughout the afternoon and on Marginal Street throughout the day until they peak from 5:00 to 6:00 PM on Tremont Street and 5:00 to 7:00 PM on Marginal Street.

Table 8 presents peak hour volumes in relation to total 24-hour weekday traffic counts. The table shows that peak hour volumes range from 4.5 percent to 8.3 percent of total weekday traffic volumes during the AM and 5.9 to 11.0 percent in the PM.

TABLE 8
OBSERVED WEEKDAY AND PEAK PERIOD
TRAFFIC VOLUMES

Street Segment	Daily* (24-hour)	AM Peak Hour	Percent of Daily	PM Peak Hour	Percent of Daily
Kneeland - EB/WB** (east of Hudson)	23,705	1,377 (8:00-9:00)	5.8	1,401 (4:00-5:00)	5.9
Harrison - SB*** (north of Bennet)	6,070	422 (10:00-11:00)	7.0	413 (5:00-6:00)	6.8
Oak**** (east of Washington)	2,439	182 (8:00-9:00)	7.5	229 (3:00-4:00)	9.4
Tremont+ (south of Stuart)	15,687	699 (9:00-10:00)	4.5	1,096 (5:00-6:00)	
Bennet++ (west of Harrison)	636	53 (10:00-11:00)	8.3	70 (12:00-1:00)	11.0
Marginal+++ (eest of Harrison)	3,518	179 (11:00-12:00)	5.1	246 (6:00-7:00)	7.0

* As recorded by mechanical counters.
** Average Monday, Tuesday, and Thursday counts.
*** Average of Tuesday, Wednesday and Thursday counts.
**** Average of Monday and Tuesday counts.
\+ Average of Tuesday, Wednesday and Thursday counts.
++ Average of Tuesday, Wednesday and Thursday counts.
+++ Average of Monday and Friday.

The peak hour traffic percentage is greater on the smaller local streets -- Oak and Bennet -- than on the arterials. Traffic volumes are generally higher throughout the study area during the afternoon than in the morning.

● Traffic Volume Levels - Character

From the perspective of neighborhood residents, traffic conditions are important not only in terms of the absolute number of vehicles using local streets or even the quality of intersection operations, but also from the standpoint of the impact of traffic on the character of the neighborhood. Quantifying the impact of increased traffic volumes on the residential character of neighborhood streets is a difficult task. Individual perceptions of how much traffic is "too much" vary considerably from person to person and in large part depend upon the conditions to which the individual is accustomed. For example, persons who have lived in a high traffic environment or who have selected their residence knowing that traffic volumes on their street were high, tend to be less concerned with traffic volume changes than persons who selected their residence because of its quiet residential character. Taking into account this diversity of perspective, it is difficult to arrive at an assessment of the impact of traffic volume increases which matches everyone's values. However, several studies have identified volume levels at which normal neighborhood activity changes. In a major research report sponsored by the U.S. Department of Transportation entitled Liveable Urban Streets (Managing Auto Traffic in Neighborhoods), streets were grouped into three categories according to daily volumes as follows:

- 2,000 vehicles per day - light volume streets
- 2,000-10,000 vehicles per day - median volume streets
- 10,000 vehicles per day - heavy volume streets

• Level of Service/Capacity Analysis

Traffic conditions, in terms of the quality of traffic flow, are expressed customarily in terms of "Level of Service" (LOS) measurements. Level of service (LOS) is the term used to denote the different operating conditions which occur at a given intersection when accommodating various volumes of traffic. It is a qualitative measure of the effect of a number of factors, including roadway geometrics, travel delay, freedom to maneuver and safety. Level of service provides an index to the operational qualities of a roadway intersection.

Level of service is represented on a scale ranging from LOS "A" at the highest level to LOS "F" at the lowest level. Level of Service A at an intersection represents a free-flow operating condition. Typically, the intersection approach appears quite open and turning movements are made easily with minimal or no delay. Levels of Service "B" through "D" represent increasingly restricted movement and delay. Capacity of the intersection occurs at the lower end of Level of Service "E", and is characterized by long queues of vehicles waiting to pass through the intersection. Level of Service "F" is usually indicative of congested conditions and represents traffic demands in excess of capacity. Table 10 summarizes the relationship of level of service, reserve capacity and expected traffic delay.

Levels of service for most of the study area's signalized intersections were determined using the Critical Movement Analysis procedure, which compares lane utilization on critical approaches to the total capacity of an intersection. The ratio of volume to capacity is inversely related to level of service, i.e., as the volume-to-capacity ratio increases toward 1.0 (volume equal to capacity) level of service declines to Level "E". Level of Service "F" represents a condition where the

network or intersection operations break down, typically due to an external factor. At two of the major study intersections -- Kneeland/ Washington and Herald/Harrison -- a more detailed method, based on delay analysis, was also applied, as recently set forth in Transportation Research Board Special Report 209.

TABLE 10
LEVEL OF SERVICE CRITERIA
FOR SIGNALIZED INTERSECTIONS*

Level of Service	Maximum Sum of Critical Volumes: Two Phase	Three Phase	Four or More Phases	Expected** Traffic Delay (Seconds)	Typical Volume/ Capacity Ratio
A	900	855	825	<5.0	0.00-0.60
B	1,050	1,000	965	5.1-15.0	0.60-0.70
C	1,200	1,140	1,100	15.1-25.0	0.70-0.80
D	1,350	1,275	1,225	25.1-40.0	0.80-0.90
E	1,500	1,425	1,375	40.1-60.0	0.90-1.00
F	- - - Not Applicable - - -			>60.0	Varies

* Transportation Research Board, Transportation Research Circular Number 212, Interim Materials on Highway Capacity, Washington, D.C., January, 1980 (Planning Criteria).

** Transportation Research Board, Special Report 209, Highway Capacity Manual, 1985.

In capacity calculations for unsignalized intersections, the assumption is made that major street movement is not affected by minor street movement and that the capacity is a function of turns within the intersection and gaps in the through traffic stream. The difference between available capacity and existing demand is defined as reserve capacity and is used as the criterion for determining level of service.

c. Highway

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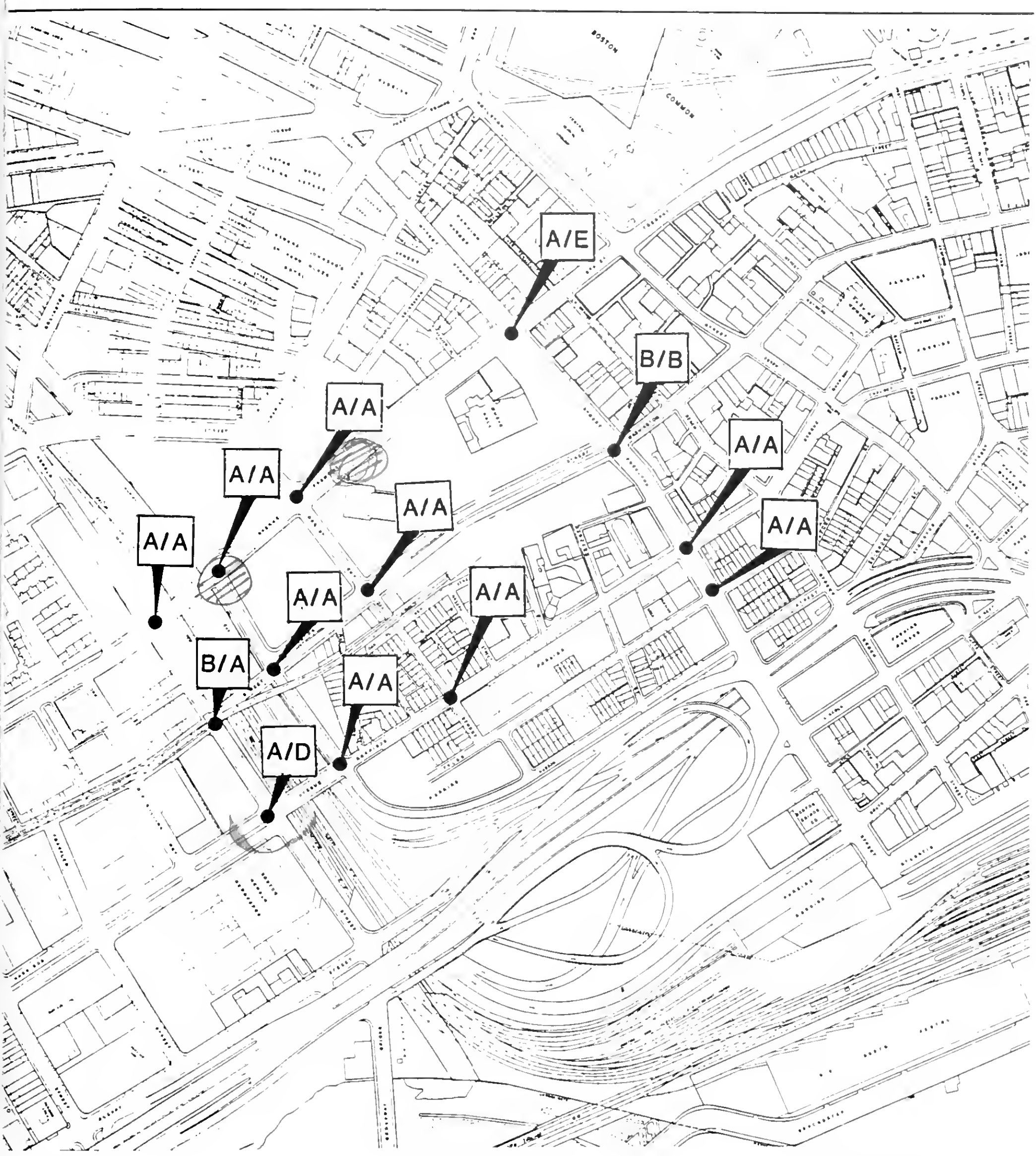
The results of the analysis are presented in Figure 8 and Table 11. The letter symbols in the upper half of the squares in Figure 8 denote LOS in the morning peak hour (usually 8:00 to 9:00 AM); the symbols in the lower half of the squares represent LOS in the afternoon peak hour (usually 4:30 to 5:30 or 5:00 to 6:00 PM).

TABLE 11
SUMMARY OF EXISTING LEVEL OF SERVICE ANALYSIS

	AM		PM	
Intersection	V/C	LOS	V/C	LOS
*Kneeland at Tyler[1]	0.46	A	0.56	A
*Kneeland at Harrison[1]	0.43	A	0.46	A
*Kneeland at Washington[2]	0.63	B	0.67	B
*Stuart at Tremont[1]	0.59	A	1.04	E
Oak at Tremont	0.24	A	0.45	A
Oak at Washington	0.36	A	0.41	A
Oak at Harrison	662[3]	A	465[3]	A
Marginal at Harrison at Hudson	0.13	A	0.21	A
Marginal at Washington	0.44	A	0.39	A
Marginal at Shawmut	0.44	A	0.41	A
Herald at Shawmut	0.30	A	0.49	A
Herald at Washington	0.55	A	0.63	B
*Herald at Harrison[2]	0.58	B	0.78	C

* = Reduction of capacity by 15 percent.
1. LOS calculation incorporates 15 percent reduction in capacity to account for pedestrian impacts on traffic flow.
2. TRB 209 Signalized Intersection analysis procedure.
3. Volume reflects available reserve capacity (ARC) of an unsignalized intersection.

The data show that traffic conditions, in terms of quality of traffic flow, are relatively good throughout the study area during the AM peak period. Most of the intersections operate at LOS "A", which denotes little or no traffic delay. The Kneeland Street/Washington Street and Herald Street/Harrison Street inter-sections are shown as operating at LOS "B" during the AM peak



Existing Intersection Level of Service Analysis

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Fig. 8

To assess the impact of the alternative parking facility sites, existing traffic volumes in the study area would be compared with projected volumes to determine if anticipated volume increases would result in a change of category for the local roadways. To facilitate this later analysis, the neighborhood streets in the study area were categorized according to current volume levels. These are summarized in Table 9.

TABLE 9
EXISTING CHARACTER OF NEIGHBORHOOD STREETS

Street	Daily Volume	Category of of Street*
Kneeland Street (east of Hudson)	23,705	Heavy volume
Marginal Street (west of Harrison)	3,518	Medium volume
Tremont Street (south of Stuart)	15,687	Heavy volume
Oak Street (east of Washington)	2,439	Medium volume
Harrison Street (north of Bennet)	6,070	Medium volume
Harrison Street** (between Oak and Marginal)	4,000	Medium volume
Hudson**	1,445	Light volume Tyler
Washington (between Herald and Marginal)	29,900	Heavy volume

* Based on criteria described in Liveable Urban Streets, Managing Auto Traffic in Neighborhoods, U.S. Department of Transportation.

** Daily volumes estimated based on peak hour flows and MRC count data.

x Title [illegible]

x Street [illegible]

table is generally expected to experience an increase in traffic volumes, the increases are not of sufficient magnitude to surpass one of the category thresholds as a result of this project in relation to any one of the alternative sites.

TABLE 25
PROJECTED CHARACTER OF NEIGHBORHOOD STREETS

Street	Daily Volume Site 1	Daily Volume Site 2	Daily Volume Site 3	Category of of Street
Kneeland Street (east of Hudson)	24,968	25,093	23,705	Heavy Volume
Marginal Street (west of Harrison)	3,950	4,139	3,518	Medium Volume
Tremont Street (south of Stuart)	15,687	15,760	15,760	Heavy Volume
Oak Street (east of Washington)	2,838	3,097	2,439	Medium Volume
Harrison Street (north of Bennet)	6,070	6,381	6,143	Medium Volume
Harrison Street** (between Oak and Marginal)	4,399	4,969	4,073	Medium Volume
Hudson**	1,877	1,756	1,445	Light Volume
Washington (between Herald and Marginal)	30,498	30,631	30,704	Heavy Volume

* Based on criteria described in Liveable Urban Streets, Managing Auto Traffic in Neighborhoods, U.S. Department of Transportation.

** Daily volumes estimated based on peak hour flows and MRC count data.

hour, denoting relatively short traffic delays. Reasons for this high level of service during the morning peak hour is that there is a minimum of conflicting traffic flow. For example, motorists turning left from Kneeland Street to Harrison Street west must cross the path of 500 oncoming vehicles on Kneeland Street during the morning peak hour versus 800 during the afternoon peak hour.

Based on flow rates, the busiest intersection in the study area during the morning peak hour is the Washington Street/ Herald Street intersection. This is a major inbound route into the study area as well as a route towards the Back Bay and the Massachusetts Turnpike Extension.

Traffic conditions are also generally good in the afternoon peak hour, although there are some trouble spots. Specifically, the Tremont Street/Stuart Street intersection is shown as operating at LOS "E" and the Herald Street/Harrison Avenue intersections are shown as operating at LOS "C", denoting moderate to relatively long traffic delays. Congestion at the Herald Street/ Harrison Avenue intersection results from heavy PM commuter traffic flows towards the Southeast Expressway. At the Tremont Street/Stuart Street intersection, traffic volumes on both streets are substantially higher in the afternoon than in morning, and as a result, this intersection is congested during the afternoon peak hour.

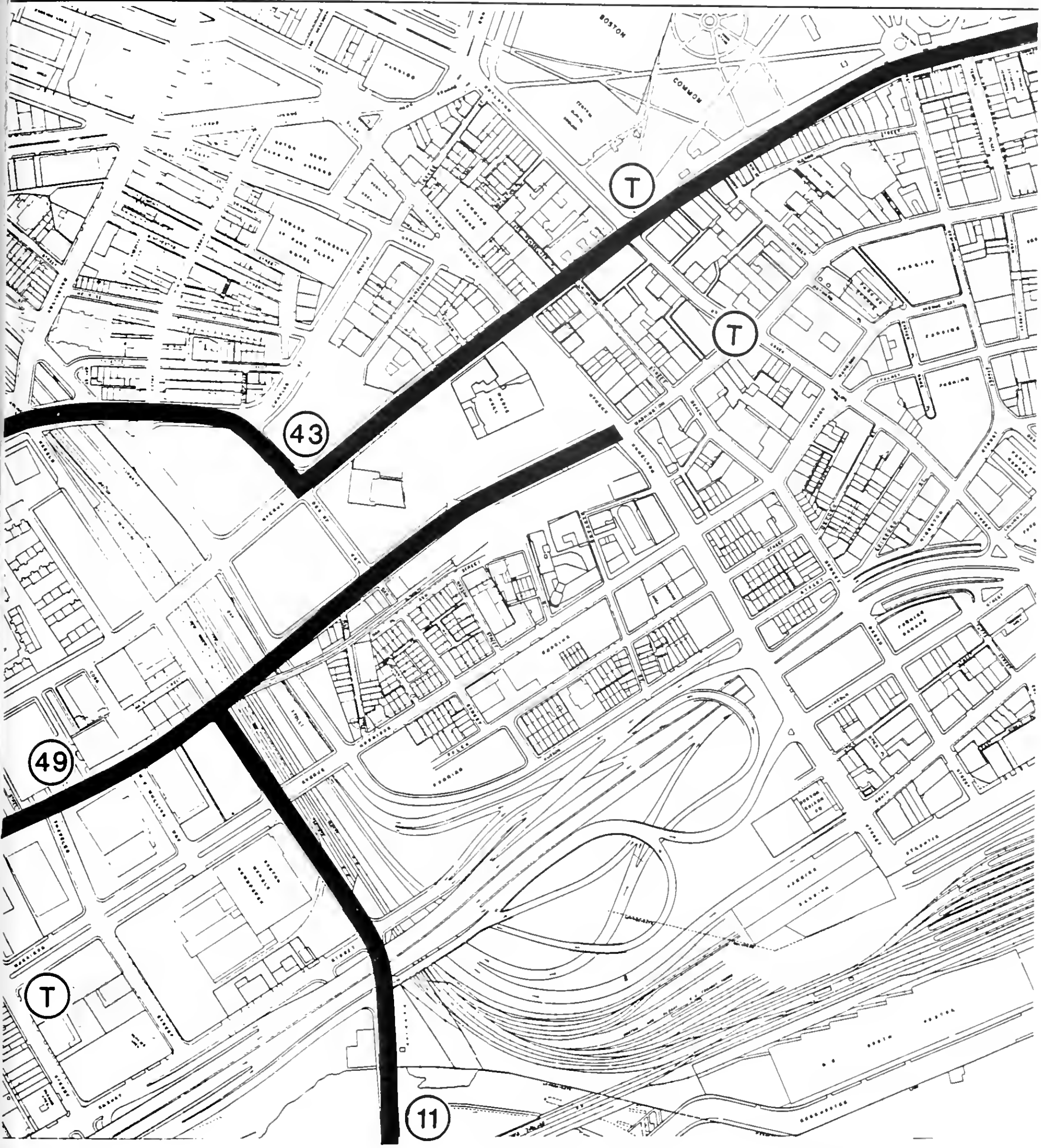
In conjunction with the level of service analysis, Vanasse/ Hangen conducted several field observations to gain a full understanding of the operation of intersections in the study area. These observations generally confirmed the LOS measurements although there are some external factors which, at times, do affect the operations of the critical intersections. Some conditions not fully reflected in the LOS analysis were the effect of upstream bottlenecks, particularly during the PM peak hour on

Herald and Kneeland Streets. Specifically, congestion related to entry onto I-93 can cause backups at intersections along Herald and Kneeland Streets, most noticeably in the case of the Herald Street/Harrison Street intersection. The condition tends to occur when there is a major delay on the Expressway possibly due to an accident or vehicle breakdown. The effects of these "shock waves" in the traffic network cannot be represented completely in the LOS analysis. However, it should be noted that at times there is congestion in the PM peak hour on Herald and Kneeland Streets, in addition to the delays at the Tremont Street/Stuart Street and Herald Street/Harrison Avenue intersections revealed by LOS analysis.

Another factor affecting traffic operations is pedestrian flow. This is particularly important along Kneeland Street where pedestrian crossings are relatively heavy over the course of the day. Most traffic signals located in the study area are equipped with pedestrian actuated pushbuttons which allow pedestrians to cross without conflicting with Kneeland Street traffic. However, field observations indicate that the pedestrian phase is rarely actuated at many locations and pedestrians tend to cross on their own, typically conflicting or delaying the movement of vehicles along Kneeland Street. Although not a continuous occurrence, this behavior does have an affect on vehicular movement increasing delays to vehicles on the major streets and at times, affecting vehicles exiting the minor streets. The impact of pedestrian crossings have been taken into account explicitly in the LOS calculations on Kneeland/Stuart Street.

3. Public Transportation

The NEMCH is in Boston's Downtown and, in general, is widely accessible by public transportation. Figure 9 shows the closest rapid transit stations and bus routes serving the study area.



Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Transit Services in NEMCH Vicinity

LEGEND:

(T) Transit Station

(#) Bus Route Number

Fig. 9

The rapid transit stops shown are the Boylston Station (approximately 1/4 mile from the hospital) on the Green Line, and the Essex and Dover Stations on the Orange Line (1,000 feet and 2,300 feet from the hospital, respectively). Just outside the borders of the figure are Park Street Station on the Red Line, Washington Station on the Red and Orange Lines, and Arlington Station on the Green Line. Bus routes directly serving the study area, as shown in the figure, are No. 9 and No. 11 from South Boston, No. 43 from Roxbury, and No. 49 from the Orange Line Northampton Station area and University Hospital.

The relocation of the Orange Line, scheduled to be completed during 1987, will eliminate the Dover Street Station located about 1,000 feet to the south of the Turnpike and nearly 2,000 feet from the central hospital area. A new Orange Line station will open in the study area itself, near the intersection of Marginal Road and Shawmut Avenue, with an entrance/exit adjacent to the Floating Hospital. A variety of options are currently under study as Orange Line replacement services on the Washington Street corridor. The improvement in service for the Medical Center due to the Orange Line relocation may result in additional transit riders to/from NEMCH. This will be discussed in more detail in connection with transportation management improvements.

It should be noted that the current public transportation system access is not as convenient to/from the study area as other sections of the Downtown. Specifically, the Red Line, which carries the highest volumes among all the MBTA transit routes, is a considerable distance from the study area. The closest Red Line Station, Washington, is over 2,000 feet from the main hospital area.

4. Signage

A well designed system of signs can serve to reduce traffic related to finding parking spaces and buildings, direct drivers to the off-street parking facilities that are most appropriate for their use, and reduce on-street parking. As part of this study, an inventory of the existing sign system was completed. Overall, there are currently few signs in the study area that either direct drivers to parking areas or orient drivers to the hospital complex.

A the intersection of Harrison Avenue and Kneeland Streets, there are small signs with arrows indicating that NEMCH is to the south on Harrison Avenue. The wall of the Dental School lists in large letters the institutions composing the Tufts/NEMCH complex, with NEMCH last on the list. Each building in the complex is identified individually on-site, but not by signs readily within the driver's field of vision. There is a 2-foot square sign in the median on Washington Street which identifies the Proger Building as the main hospital entrance. A large sign identifies the Floating Hospital.

Although each off-street parking facility is identified on-site, there are no signs on campus directing drivers to the location of parking facilities. The signs identifying the Tremont Street garage as being for patient and visitor use are removable and placed at ground level. The two facilities where patients and visitors are allowed to park (i.e., Tremont Street Garage and Posner Lot) post rates in locations that are not optimal from the standpoint of the driiver's field of vision. Signs at these facilities also do not indicate whether spaces are available or full, or where additional parking spaces (at another facility) may be found. A sign is posted at the Oak Street lot indicating

whether both the Oak Street lot and Herald Street garage are open.

5. Hospital Transportation Management Programs

NEMCH has undertaken a number of program initiatives intended to encourage the use of public transportation and high occupancy vehicles by its employees, thereby reducing the frequency of automobile travel to and from the hospital. Coordination of transportation management is the responsibility of the parking manager, a position created in the fall of 1985. These actions are described in this section.

• MBTA Monthly Pass Distribution

↓ subsidy?

The hospital sells MBTA monthly passes at its Head Cashier's Office during the last three working days of each month. Approximately 325 to 330 passes are sold monthly.

• Ridesharing

Caravan for Commuters, Inc., a non-profit corporation administering third-party vanpool and other transportation-management programs, has conducted several presentations at the hospital regarding vanpooling. However, insufficient interest has been demonstrated to initiate a formal ridesharing program. There are several factors which probably account for the lack of response among NEMCH employees:

- Availability of relatively high quality public transportation service;

- Wide variation in arrival and departure times among hospital staff;

- Broad dispersion of staff trip origins.

The last two factors will be discussed in greater detail as part of the evaluation of potential transportation management improvement actions, in Section III of this report.

- <u>Identification of Potential New Public Transportation Users</u>

The NEMCH parking office is developing a computerized database which will enable it to identify employees who reside near public transportation services. The parking advisory committee has the authority to deny monthly parking passes to employees who can access the hospital conveniently by public transportation.

- <u>Subway Escort Service</u>

The hospital makes available to all of its employees an escort service to area subway stations. This service is subsidized through parking revenues.

6. Travel Behavior Characteristics of the Hospital Population

A Transportation Questionnaire Survey of the NEMCH and Tufts populations was conducted on May 1, 1986. The purpose of the survey was to obtain information on the travel behavior characteristics of all persons traveling to the hospital or using hospital parking facilities. This information was required to determine the routes traveled by persons driving to the hospital, and to evaluate potential transportation management innovations. Key types of data collected through the survey were as follows:

- Mode of transportation to the hospital.

- Origin of trips to the hospital.

- Time of arrival and departure at the hospital.

- Variations in travel behavior by user groups (e.g., hospital staff, patients, visitors, students).

- Parking location of those who drove

The survey was administered in the form of a single-page questionnaire, which was distributed to all persons entering the Tufts-NEMCH complex at 12 locations. The questionnaire distribution points were chosen to provide a representative sample of the daily population traveling to NEMCH and/or using associated parking facilities. Approximately 4,300 surveys were distributed, of which 2,080 were returned, yielding a response rate of 48 percent. A copy of the survey questionnaire and the raw data/frequency distributions of responses to the survey are presented in Appendix B to this report. The survey findings are briefly summarized below.

- <u>Mode of Transportation</u>

Among a total of 1,604 survey respondents reporting their mode of transportation to the hospital,[2] the distribution of responses was as shown in Table 12.

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2/ Does not include persons receiving questionnaire at the Tremont Street Garage.

TABLE 12
MODE CHOICE OF NEMCH POPULATION

	Frequency	Percent
Drove	691	42.9
Passenger in vehicle that parked	58	3.6
Dropped off by car	71	4.4
Subway	502	31.1
Bus	86	5.3
Commuter rail	37	2.3
Taxi	20	1.2
Walked	109	6.8
Bicycle/motorcycle	30	1.9
Vanpool	8	.5
Total		

49.9

The results indicate that approximately 43 percent of all trips to the hospital are made by someone who drives and parks a car or other private vehicle. Taking into account automobile passengers and persons dropped off by automobile, just over 50 percent of the survey sample can be classified as automobile users, although the proportion of parkers is approximately the same as the proportion of drivers (i.e., 43 percent).

Transit users constitute approximately 39 percent of the sample. Most of these are subway riders, who represent 31 percent of the total number of people traveling to the hospital on a typical weekday. Over 5 percent of the sample travel to the hospital by bus, and approximately 2 percent use commuter rail.[3] The survey included a question which asked those who travel to

====================

3/ The survey was conducted on a day when several commuter rail lines were not in service, due to an employee strike. However, only .4 percent of the respondents reported that they usually travel by commuter rail, although not on the day of the survey.

the hospital by subway to indicate the station at which they get off the train. The distribution of subway riders by station is shown in Table 13.

TABLE 13
DISTRIBUTION OF SUBWAY RIDERS BY STATION

Station	Frequency	Percent
Essex Street	227	42%
Boylston Street	167	31
Washington Street	83	15
Park Street	45	8
Arlington Street	2	<1
Broadway	8	1
Copley	3	<1
State Street	5	1
Total	540	

Over 40 percent of those accessing the hospital by subway do so via the Orange Line's Essex Street Station, which is the station closest to the NEMCH complex. Approximately 31 percent of subway users access the study area via Boylston Station on the Green Line, which is the next-closest station in relation to the hospital. A total of 23 percent of the subway users are Red Line riders; 15 percent exit trains at Washington Street and 8 percent leave the subway at Park Street. The low proportion of Red Line riders relative to users of the Green and Orange Line can be explained by the fact that the Red Line stations are farther from the hospital complex than are the Essex and Boylston Street Stations. Since both the Washington and Park Street Stations are more than one-quarter mile from the hospital, it is to be expected that the Red Line mode share would be substantially lower for NEMCH-related trips than for trips to locations in the center of Downtown Boston (e.g., financial and shopping

districts). Many of those reporting use of the Essex Street Station may have transferred from the Red Line. The need to transfer, however, increases the total travel time and inconvenience associated with transit use, which would have the effect of reducing Red Line ridership among NEMCH employees.

Among those who travel to the hospital by bus, the distribution of riders by bus route is shown below in Table 14.

TABLE 14
DISTRIBUTION OF BUS RIDERS BY ROUTE

	Frequency	Percent
Route 11 - Essex & Washington	36	40.4
Route 39 - Copley Station	1	1.1
Route 43 - Park Street	1	1.1
Route 49 - Essex & Washington	1	1.1
Route 55 - Copley Square	2	2.2
Route 93 - Haymarket	1	1.1
Route 300 - South Station	3	3.4
Route 301 - South Station	10	11.2
Route 304 - South Station	6	6.7
Route 305 - South Station	6	6.7
Others	21	23.6

Mode choice behavior was examined in greater detail to determine whether hospital employees differ from patients, visitors, students, and other categories of travelers to the hospital, with respect to their reliance on the automobile. The results are presented in Table 15. According to the survey, approximately 45 percent of the hospital staff, which includes physicians, nurses and other employees, drive to work and park. Expanded to the estimated weekday population of 3,800 NEMCH employees, this percentage translates into approximately 1,720 employees who

TABLE 15
MODE CHOICE BY USER CATEGORY

User Category	Drive		Passenger in Vehicle that Parked		Drop-Off		Subway		Bus		Commuter Rail		Taxi		Walk		Bicycle/ Motorcycle		Vanpool		Total
NEMCH Staff	343	44.7 (%)	15	2.0 (%)	37	4.8 (%)	245	31.9 (%)	46	6.0 (%)	27	3.5 (%)	4	0.5 (%)	29	3.8 (%)	13	1.7 (%)	8	1.0 (%)	767
Patients, Visitors, and Other NEMCH-Related	265	48.4 (%)	38	6.9 (%)	25	4.6 (%)	131	23.9 (%)	29	5.3 (%)	1	0.2 (%)	16	2.9 (%)	38	6.9 (%)	4	0.7 (%)	0		547
Tufts-Related	80	28.0 (%)	5	1.7 (%)	9	3.1 (%)	120	42.0 (%)	9	3.1 (%)	9	3.1 (%)	0		41	14.3 (%)	13	4.5 (%)	0		286

NOTE: Percentages add across.

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drive to the hospital on a typical weekday. This is a lower percentage of drivers than is found among visitors and patients (48.4 percent). Only a small percentage of employees arrive at the hospital as passengers in cars driven by others. Approximately 38 percent of the hospital staff uses public transportation to travel to work, which is higher than the rate of transit use among visitors and patients (29 percent).

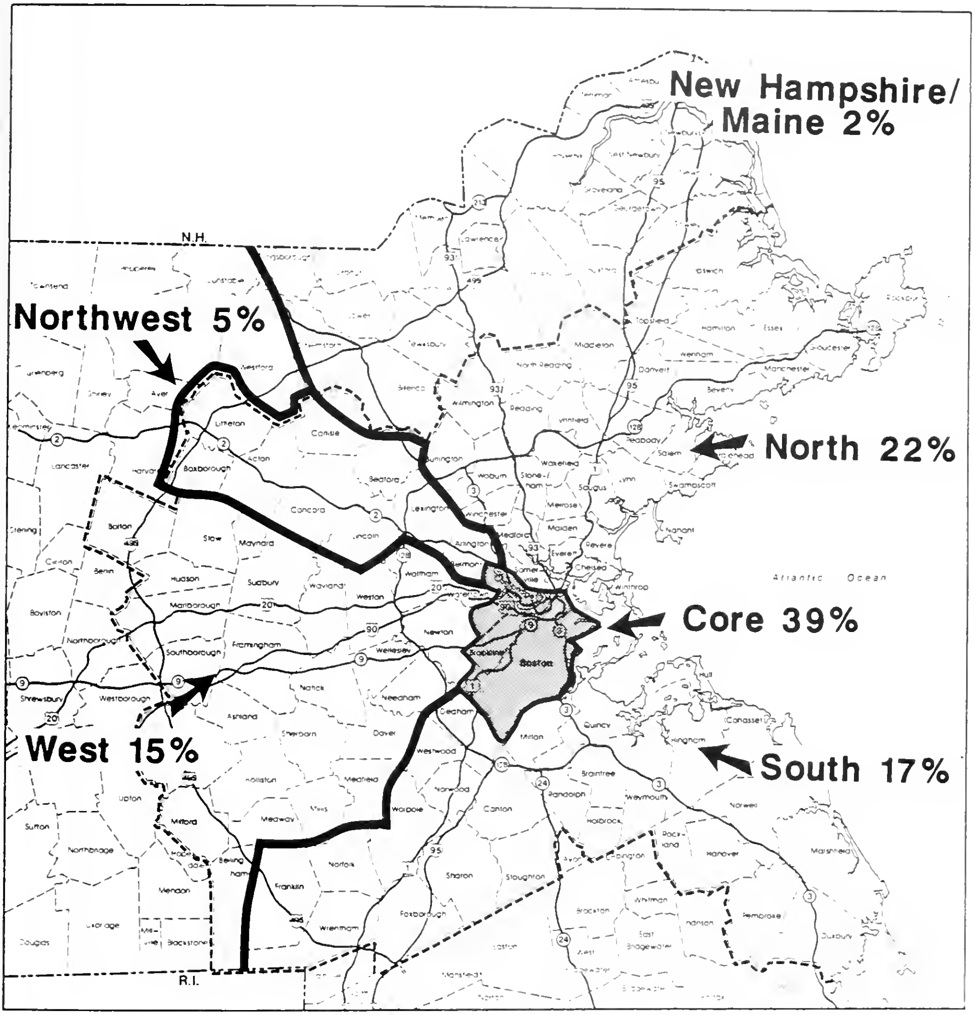
45
78
83

• Vehicle Occupancy

Vehicle occupancy data were also collected through the survey to determine the extent of current ridesharing activity, including both carpooling and vanpooling. Among all vehicles driven to the study area there is an average of 1.43 occupants per vehicle. Among employees, average auto occupancy declines to 1.08, while among hospital visitors and patients there is an average of 1.48 occupants per vehicle. For trips related to Tufts University activities, average vehicle occupancy is 1.16.

• Origin/Destination Patterns

Figure 10 shows the distribution of weekday trips to the Tufts/NEMCH complex by area of origin. The area to the north of the metropolitan core accounts for 22 percent of all trips to Tufts/NEMCH. The northwest contributes 5 percent of all trips to the complex; the west, 15 percent; and the south, 17 percent. Two percent of all trips originate in New Hampshire and Maine, while the metropolitan core area, defined as Boston, Cambridge, and Brookline, accounts for 39 percent of all Tufts/NEMCH trips. Trips originating in the core are further broken down by city/town and neighborhood in Table 16.



Vanasse Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Distribution of Tufts/NEMCH Trips by Origin

Fig. 10

TABLE 16
CORE AREA TRIPS TO TUFTS/NEMCH COMPLEX:
DISTRIBUTION BY TOWN

Community	Response Frequency	Percent of Core Area Trips to Tufts/NEMCH
Brookline	100	12
Cambridge	64	8
Boston	644	80
Back Bay	26	3
Beacon Hill	13	2
Allston/Brighton	97	12
Charlestown	13	2
Jamaica Plain	47	6
Chinatown	7	1
Dorchester	103	13
East Boston	28	3
Fenway	7	1
Forest Hills	1	<1
Hyde Park	14	2
Kenmore Square	3	<1
Mattapan	23	3
Mission Hill	3	<3
North End	2	<1
Readville	1	<1
Roslindale	23	3
Roxbury	18	2
Savin Hill	2	--
South Boston	77	10
South End	25	3
West End	3	4
West Roxbury	13	2
Unspecified	95	12
Total Core	808	100

NOTE: Based on 5/1/86 questionnaire survey conducted at NEMCH.

As the table shows, Boston contributes most of the Tufts/NEMCH trips originating in the core area. Within the City of Boston, Allston/Brighton, Dorchester, and South Boston, each generate over 10 percent of all core area trips to the hospital complex. Conversely, only 1 percent of the reported origins were from the Chinatown neighborhood.

The mode choice distribution for persons whose trips originate in selected areas of Boston, where public transportation is often convenient, is presented in Table 17. The areas selected for illustration each account for 3 percent or more of core area trips to the hospital complex. The percentage of people driving to the hospital is greatest in Roslindale (65 percent), Dorchester (53 percent) and Jamaica Plain (50 percent). The subway mode share is highest from East Boston (64 percent), Mattapan (48 percent), and Allston-Brighton (42 percent). The only neighborhoods showing a bus mode share of 10 percent or more are South Boston (48 percent) and Allston-Brighton (10 percent). The relatively high bus mode share in South Boston is not surprising, given that two of the four bus route, No. 9 which enters the study area, originates in South Boston.

- Parking Location

The relative use of different parking areas is shown in Table 18 for three different categories of survey respondents: NEMCH staff; hospital visitors and patients; and Tufts-related individuals (e.g., faculty, students). The predominant users of all facilities, except the Posner Lot on Harrison Avenue, are NEMCH employees, although substantial numbers of patients and visitors use the Tremont Street Garage, and over 35 percent of those parking in the Herald Street Garage are Tufts-related individuals (predominantly students). Of the 120 reported

TABLE 17
MODE CHOICE FOR SECTIONS OF BOSTON

User Category	Drive		Passenger in Vehicle that Parked		Drop-Off		Subway		Bus		Commuter Rail		Taxi		Walk		Bicycle/ Motorcycle		Vanpool		Total
Allston-Brighton	38	39.0 (%)	2	2.0 (%)	4	4.0 (%)	41	42.0 (%)	10	10.0 (%)	--	--	--	--	1	1.0 (%)	1	1.0 (%)	--	--	97
Back Bay	4	15.0 (%)	--	--	2	8.0 (%)	7	27.0 (%)	--	--	--	--	1	4.0 (%)	11	42.0 (%)	1	4.0 (%)	--	--	26
Jamaica Plain	23	50.0 (%)	1	2.0 (%)	2	4.0 (%)	17	37.0 (%)	1	2.0 (%)	--	--	1	2.0 (%)	--	--	1	2.0 (%)	--	--	46
Dorchester	55	53.0 (%)	4	4.0 (%)	5	5.0 (%)	32	31.0 (%)	1	1.0 (%)	1	1.0 (%)	--	--	3	3.0 (%)	1	1.0 (%)	1	1.0 (%)	103
E. Boston	7	25.0 (%)	2	7.0 (%)	1	4.0 (%)	18	64.0 (%)	--	--	--	--	--	--	--	--	--	--	--	--	28
Mattapan	8	35.0 (%)	--	--	2	9.0 (%)	11	48.0 (%)	2	9.0 (%)	--	--	--	--	--	--	--	--	--	--	23
Roslindale	15	65.0 (%)	--	--	--	--	8	35.0 (%)	--	--	--	--	--	--	--	--	--	--	--	--	23
S. Boston	20	26.0 (%)	4	5.0 (%)	3	4.0 (%)	3	4.0 (%)	37	48.0 (%)	--	--	2	3.0 (%)	6	8.0 (%)	2	3.0 (%)	--	--	77
S. End	--	--	--	--	1	4.0 (%)	6	24.0 (%)	1	4.0 (%)	--	--	1	4.0 (%)	15	60.0 (%)	1	4.0 (%)	--	--	25

NOTE: Percentages add across.

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TABLE 18
PARKING LOCATION BY USER CATEGORY

Location/ User Category	Tremont St. Garage		Shopper's Garage		Posner Lot		Oak St. Lot		Washington St. Lot		Herald St. Garage		Hospital Parking Facility Total (Sum of Columns 1-6)		Outside Hospital Parking Facilities*		Unspecified		Total
NEMCH Staff	116	34.0 (%)	12	4.0 (%)	33	10.0 (%)	25	7.0 (%)	13	4.0 (%)	90	27.0 (%)	289	85.0 (%)	43	13.0 (%)	7	2.0 (%)	339
Patients, Visitors and Other NEMCH-Related	84	32.0 (%)	4	2.0 (%)	85	32.0 (%)	7	3.0 (%)	24	9.0 (%)	4	2.0 (%)	208	80.0 (%)	47	18.0 (%)	7	2.0 (%)	262
Tufts-Related	8	10.0	--	--	2	3.0	1	9.0	--	--	62	79.0	73	94.0	5	6.0	0		78
Total Responses	108		16		20		33		37		156		570		95		14		679

NOTE: Percentages add across.
* Predominantly on-street.

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parkers in the Posner Lot, over 70 percent are patients and visitors at the NEMCH.

The table shows that the vast majority of survey respondents park in NEMCH-controlled facilities. The frequency of parking outside NEMCH facilities, usually on-street, varies by user category, ranging from 6 percent for Tufts-related respondents to 18 percent for NEMCH patients and visitors. The survey indicates that approximately 13 percent of NEMCH employees park on-street or in other spaces outside of NEMCH parking facilities. When the survey results are expanded to the population of NEMCH employees, it is estimated that approximately 1,500 employees park in NEMCH off-street parking spaces, and 220 employees park elsewhere.

B. FUTURE CONDITIONS

The NEMCH's parking needs in the planning horizon year of 1990 will be influenced by any growth in hospital activities which occurs in the four years between then and now. Another concern of relevance to the planning of hospital transportation services is any change in study area traffic conditions which may occur by 1990. Vanasse/Hangen has analyzed the factors which could contribute to both increased parking demands and vehicle traffic during the next four years. This analysis has included identifying non-NEMCH projects which could affect study area travel demands as well as NEMCH growth itself. The results of this analysis are presented below.

1. Future NEMCH Parking Needs

Two different indicators of potential hospital growth were examined: patient population growth patterns, and facility development plans.

- **Patient Population**

Annual patient census data are presented in Table 19 for the years 1981 to 1986. Figures shown for 1986 are NEMCH projections. The data show some fluctuations from year to year, and there is no evidence of sustained growth in patient activity. The strongest trend which emerges is a small decline in the number of annual patient days, a measure which typically is highly correlated with both staff population and visitor trips to the hospital. NEMCH projects that all three measures shown in Table 19 will remain constant at projected 1986 levels through the planning horizon year of 1990. Compared to 1985 data, the number of clinic visits was projected to rise by 2 percent, and admissions were estimated to increase by 3 percent, in 1986. The parking and traffic data presented earlier in this report were collected in April of 1986, however, and presumably reflect a substantial proportion of the growth that had been anticipated for the current year. Since the number of patient days was projected to decline slightly, it is reasonable to conclude that the total NEMCH population will not change significantly from current levels through the end of 1986 and further into the future through 1990.

TABLE 19
NEMCH PATIENT CENSUS DATA

Clinic Visits		Patient Days	Admissions (In Patients)
1981	247,593	145,363	13,658
1982	258,995	139,170	13,546
1983	253,871	142,503	14,163
1984	242,998	142,180	13,653
1985	245,771	136,879	13,870
1986	251,087*	136,530*	14,300*

SOURCE:

• Facility Development

Viewing potential growth from the standpoint of facility development, no major change at the NEMCH is projected through 1990 according to NEMCH planners. NEMCH does plan to construct a new facility, designated as the 1C Building, in the central section of NEMCH complex, near the Proger Building. This facility will house the adult nursing units presently located in the Pratt-Farnsworth Building, and possibly a maternity unit of approximately 20 beds. The future relocation of activities from Pratt-Farnsworth represents a shift of population within the complex, rather than an increase in NEMCH population. The 20-bed maternity unit is expected to result in a negligible increase in the total hospital population.

The most likely use of the Pratt-Farnsworth Building, after its present functions are moved to 1C, is for research. The 155,810 square foot building could potentially house approximately 686 employees based on assumed 4.4 employees per 1,000 square feet. In the event this occurs, it would generate additional daily parking demands of approximately 273 spaces each weekday. Peak parking demands may be somewhat less. Based on discussions with NEMCH staff, this reuse plan and related increase in parking demand would occur after 1990.

In summary, based on review of historical patient activity trends and projections, and discussions with NEMCH staff regarding specific development projects, it is not anticipated that a significant change in parking demand will occur at NEMCH through the year 1990. Longer term increases may be expected to be in the range of 150 to 200 spaces.

2. Background Development

The impacts of anticipated future development on study area traffic conditions was estimated, in terms of both peak hour traffic volumes and intersection level of service. These impacts were then incorporated into the study framework as elements of background future conditions, which serve as a baseline against which the further impacts of any increase in NEMCH parking supply can be assessed, in Section II of this study.

A number of specific projects were identified, upon consultation with the Boston Redevelopment Authority, which were judged to have the potential to affect study area traffic conditions by the year 1990. These projects, and their associated impacts with respect to trip generation, are shown in Table 20.

Trip generation factors for the residential development projects are from the Institute of Transportation Engineer's Trip Generation Manual,[4] modified to reflect the 14 percent auto mode share for the Boston CBD residents reported in the 1980 U.S. Census. Trip generation and mode share factors for the office/ commercial development are based on actual BRA building surveys conducted during the 1982 Downtown Boston Parking Study.[5]

To determine the impacts of the above projects on study area traffic conditions, trips generated by the projects were assigned to Downtown streets in accordance with existing downtown origin-destination patterns, and changes in traffic volumes on roadways in the study area were estimated.

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4/ Institute of Traffic Engineers, Trip Generation and Information Report; Washington, D.C., Rev. 1982.

5/ Cambridge Systematics, Inc., Parking in Central Boston, performed for City of Boston, 1983.

TABLE 20
ESTIMATED TRIPS GENERATED BY NEW PROJECTS
YEAR 1990

Project	Total Weekday Trips	AM Peak Hour Vehicle-Trips	PM Peak Hour Vehicle-Trips
Within Study Area			
-- Housing 200 units Don Bosco Site Tremont Street	140*	9	12
-- Housing 200-225 units 172-200 parking spaces R3/E3A Site Oak/Washington/ Marginal	150*	9	12
-- Housing 60-75 units R1 Site Hudson/Tyler	53*	3	2
Outside Study Area			
-- Bedford/Kingston Site Phase I 700,000-900,000 sq. ft.** office commercial	6,075	200	200
-- Hayward Place Maximum 500,000 sq.ft.** commercial	3,375	112	112

* AM and PM peak hours combined.
** Assumed occupancy rate of 50 percent in 1990.

To account for study area traffic growth associated with general development in the Back Bay and other more distant areas, an annual background traffic growth rate of 2 percent was aslo applied on the major arteries including Kneeland, Stuart and Herald Streets. A 1 percent annual background traffic growth rate was applied on the remaining streets in the study area, again to account for general growth associated with projects outside of the study area for this project.

- **Traffic Volume Analysis**

The impacts of growth are reflected in the 1990 No-Build traffic networks, shown in Figures 11 and 12. Changes in traffic volumes on roadways in the study area are shown in Table 21. Compared to existing conditions, the largest increases in traffic will be on Kneeland Street between Washington and Harrison Streets, where volumes will rise by approximately 146 vehicles in the AM peak hour and 65 vehicles in the PM peak hour, and on Herald Street between Washington and Harrison Streets, where increases will be on the order of 53 vehicles in the AM peak and 125 vehicles in the PM peak.

- **Level of Service/Capacity Analysis**

The effects on level of service resulting from estimated traffic volume increases are presented in Table 22, which compares volume/capacity ratios and LOS measurements for intersections in the study area under existing conditions and for the year 1990.

The analysis results indicate some changes from existing conditions as follows. A small decline in LOS from "B" to "C" in the AM peak hour at the Kneeland/Washington intersection; a decline from "A" to "B" in the AM peak hour at the Stuart Street/Tremont Street intersection; a decline from "A" to "B" in the AM peak hour at the Herald Street/Harrison Avenue intersection; and a decline from "A" to "B" in the PM peak hour at the Herald Street/Washington Street intersection. All of these impacts are relatively minor in magnitude, and all of the intersections in the study area will continue to operate at acceptable levels of service in 1990. It should be noted that the same factors discussed previously including the Expressway operating conditions and pedestrian activity can affect traffic flow in

1990 No Build A.M. Peak Hour Traffic Volumes

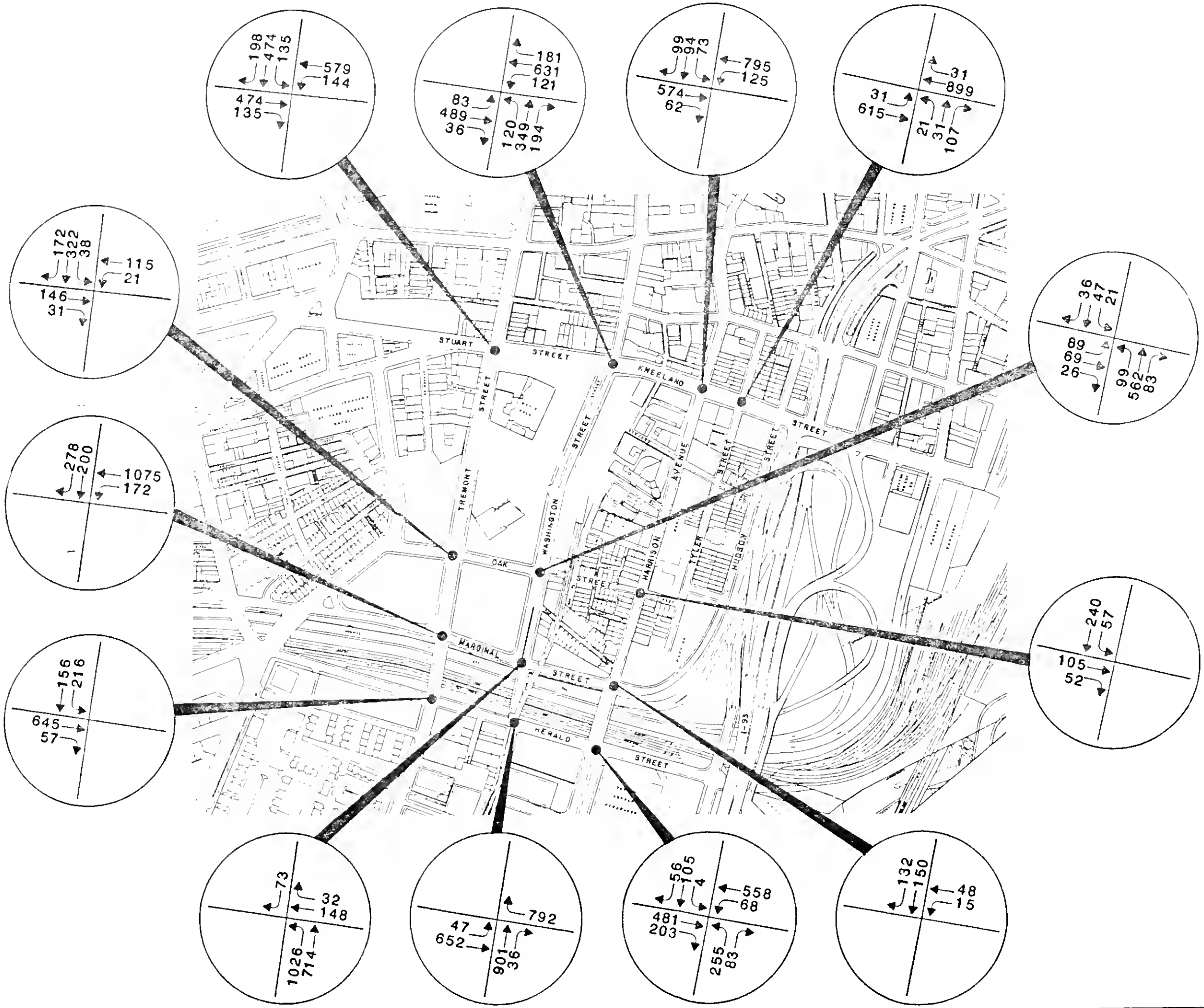

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Fig. 11

1990 No Build P.M. Peak Hour Traffic Volumes

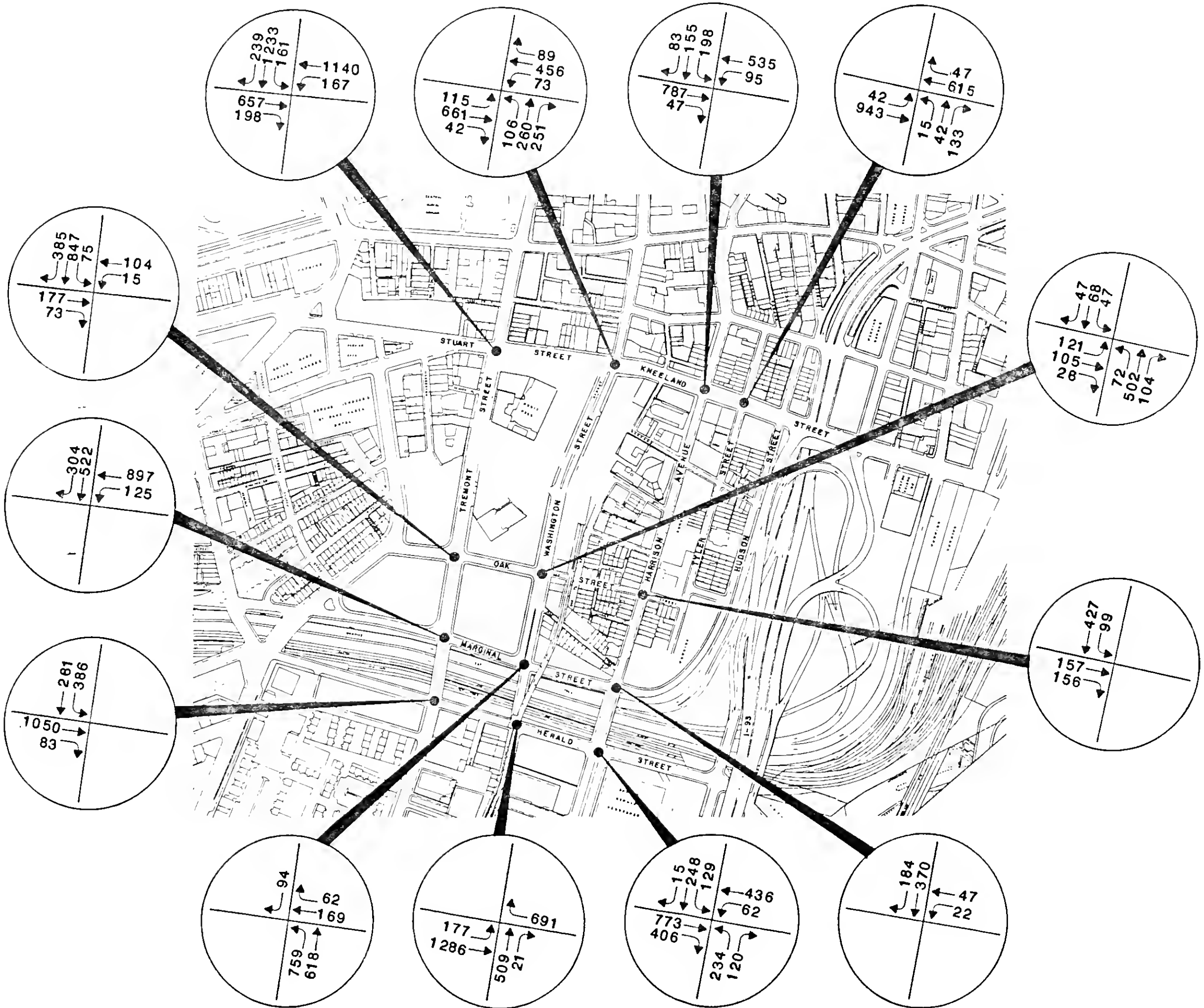

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Fig. 12

TABLE 21
CHANGES IN STUDY AREA TRAFFIC VOLUMES: 1986-1990 (NO-BUILD)

Location	NUMBER OF VEHICLES				CHANGE	
	Existing Conditions		1990 No-Build		1986 to 1990	
AM	AM	PM	AM	PM	AM	PM
o Kneeland between Washington and Harrison	815 (WB)	590 (WB)	933	618	118	28
	655 (EB)	875 (EB)	683	912	28	37
o Stuart between Tremont and Washington	670 (WB)	1,250 (WB)	723	1,307	53	57
	585 (EB)	785 (EB)	608	818	23	33
o Marginal between Shawmut and Washington	1,195 (WB)	980 (WB)	1,247	1,022	52	42
o Washington between Herald and Marginal	1,645 (NB)	1,320 (NB)	1,740	1,377	95	57
o Herald between Washington and Harrison	655 (EB)	660 (WB)	684	691	29	31
	834 (WB)	1,160 (EB)	866	1,179	32	19
o Tremont between Stuart and Oak	720 (SB)	1,530 (SB)	753	1,598	33	68
o Herald between Washington and Albany	521 (EB)	920 (EB)	568	1,021	47	101
	600 (WB)	475 (WB)	626	499	26	24
o Oak between Washington and Harrison	165 (EB)	300 (EB)	173	313	8	13
o Harrison between Oak and Marginal	280 (SB)	540 (SB)	292	554	12	14
o Hudson	60 (SB)	60 (SB)	63	69	3	9
o Tyler	155 (NB)	245 (NB)	159	256	4	11

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terms of reducing the number of vehicles processed through an intersection and adding delays to motorists.

TABLE 22
SUMMARY OF NO-BUILD LEVEL OF SERVICE ANALYSIS

	Existing Conditions				1990 No-Build -Garage ?			
	AM		PM		AM		PM	
Location	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS
Kneeland Street/ Tyler Street	0.46	A	0.56	A	0.51	A	0.57	A
Kneeland Street/ Harrison Avenue	0.43	A	0.46	A	0.56	A	0.57	A
Kneeland Street/ Washington Street	0.63	B	0.67	B	0.71	C	0.70	B
Stuart Street/ Tremont Street	0.59	A	1.04	E	0.62	B	1.10	E
Oak Street/ Harrison Avenue	--	A	--	A	--	A	--	A
Oak Street/ Washington Street	0.36	A	0.41	A	0.42	A	0.43	A
Oak Street/ Tremont Street	0.24	A	0.45	A	0.26	A	0.47	A
Marginal Street/ Harrison Avenue	0.13	A	0.21	A	0.14	A	0.23	A
Marginal Street/ Washington Street	0.44	A	0.39	A	0.48	A	0.40	A
Marginal Street/ Shawmut Avenue	0.44	A	0.41	A	0.46	A	0.43	A
Herald Street/ Harrison Avenue	0.30	A	0.49	C	0.60	B	0.87	C
Herald Street/ Washington Street	0.55	B	0.63	A	0.66	B	0.61	B
Herald Street/ Shawmut Avenue	0.58	A	0.78	A	0.32	A	0.52	A

TRANSPORTATION EVALUATION OF ALTERNATIVE FACILITY SITES

SECTION II

TRANSPORTATION EVALUATION OF ALTERNATIVE FACILITY SITES

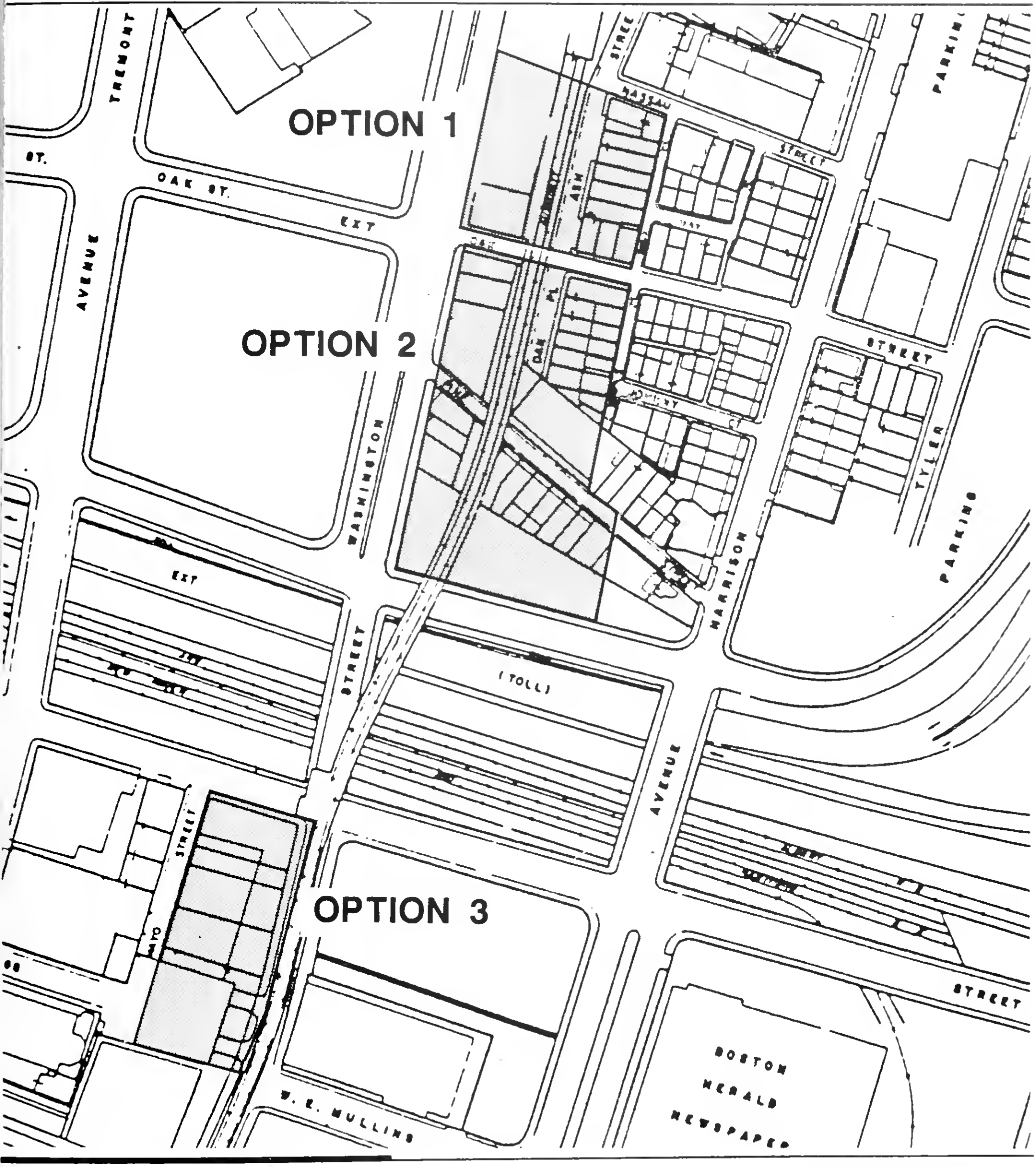
Limited parking facility expansion has been a consistent element of NEMCH's capital planning program. The 1982 Facilities Master Plan did, however, include a major parking facility as part of the 1C development to be built in the central section of the NEMCH complex. As a result of that 1982 study, NEMCH is presently considering three alternative sites as locations for a new 850-space parking garage to serve hospital employees. The chief purposes of this facility would be to:

- Address the hospital's demonstrated need for additional spaces;
- Consolidate parking supplies, which are currently dispersed at six locations, two of these being some distance from the NEMCH complex;
- Secure the hospital's parking supply, some of which is currently made available to the NEMCH under short-term leasing arrangements that can be terminated upon lease expiration.

This section of the report focuses on evaluation of the three alternative parking garage sites being considered by NEMCH.

A. DESCRIPTION OF ALTERNATIVE SITES

The three alternative garage sites are shown in Figure 13. Site 1 is a site at the corner of Washington and Oak Streets, extending northward to Nassau Street. Although different configurations are being explored by NEMCH, this site is approximately 200 feet by 200 feet. Site 2, the R3/R3A site, is directly to



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Alternative Parking Facility Sites

Fig. 13

the south of Option 1, across Oak Street. The parcel is bounded by Oak, Washington and Marginal Streets, as well as existing residential buildings on the R3B site. This site has the largest footprint, being approximately 300 feet by 160 feet. Site 3, the SCM building at 50 Herald Street, is over 300 feet to the south of the southern edge of the R3/R3A parcel, across the Massachusetts Turnpike. The site, which has approximate dimensions of 115 ffet by 295 feet, is bounded by Herald Street on the north and Washington Street on the west.

NEMCH's current plans are to construct an 750-space to 850-space facility at whichever of the sites is selected. A conservative or worst case analysis assumed an 850-space garage. From a parking needs perspective, therefore, all three sites are equal. Viewed in terms of scale, all three sites are similar, in that the parking facility must be sized to accommodate 850 spaces. The surface area available at each site does vary, however, and dictates the size of the proposed facility's footprint. Where a smaller footprint is necessitated, the height of the structure must increase. The largest of the three alternatives parcels is Option 2, the R3/R3A site, and an above ground five-level structure, roughly 50 feet in height, could be built on this site. Depending on the specific design configuration chosen, an 850-space structure on the Oak Street site (Option 1) would be 7 to 10 levels, or 70 to 100 feet in height. The dimensions of the SCM site (Option 3) dictate that an 850-space structure be 10 levels, or 100 feet above ground level.

B. GENERAL EVALUATION

The evaluation of the three alternative sites focused on determining the relative impacts or changes in traffic flow, air quality and noise conditions when compared to the 1990 No-Build

condition. These evaluation results are discussed in some detail later in this and the following report sections.

In addition to the above, the following areas were examined or identified:

- parking layout efficiency,
- height of structure,
- pedestrian accessibility,
- vehicle accessibility, and
- land use.

Table 23 briefly summarizes this overall evaluation with respect to the above five criteria.

In evaluating the sites in terms of parking efficiency, site dimensions and configuration are taken into account. In general, both Site 1 and Site 2 can result in parking facilities with above average circulation and space layout. Site 2 is more advantageous because of its larger footprints which allows for flexibility in meeting accepted deign standards. Site 3, on the other hand, has a narrow site (approximately 110 to 114 feet wide) which will affect the design of the structure as well as require several more floors to provide the same number of spaces as Sites 1 and 2. As a result, circulation and maneuvering within a facility on Site 3 will be below average. It should be noted that variances in setbacks will also likely be required to build this facility.

From the standpoint of pedestrian access, Sites 1 and 2 are clearly superior to Site 3. Site 1 is adjacent to the center of the hospital complex. Pedestrian access to and from the site is therefore judged to be excellent. Site 2, while convenient to the hospital, requires pedestrians to cross Oak Street en route to the main NEMCH facilities, and is slightly farther from the

TABLE 23
EVALUATION CRITERIA MATRIX

Site	Efficiency	Height	Pedestrian Access	Local Vehicle Access	Primary Traffic Impact	Alternate Land Use
Site 1 Oak Street/ Washington/ Nassau	Above average	7-10 Levels	Excellent	Good*	Washington Kneeland	Institutional
Site 2 R3/R3A	Above average	5 Levels	Good	Good*	Washington Oak Harrison	Residential
Site 3 SCM	Below average	10 Levels	Poor	Fair	Herald Harrison Herald/ Washington Intersection	Commercial

* Presumes median break on Washington Street.

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center of hospital activity. Pedestrian access characteristics for this option are described as "good" in the table, and in fact are roughly comparable to those of Site 1. Site 3 is approximately 1/4-mile from the center of the NEMCH complex. Pedestrians walking between this site and the hospital would have to cross over the Turnpike on the Washington Street Bridge. A facility on this site would function essentially as a "remote" parking option, requiring the operation of a shuttle bus service between the site and the NEMCH complex. Pedestrian access between the hospital and this site is judged to be poor.

Table 23 characterizes vehicle access to sites 1 and 2 as being "good", assuming a median break is provided on Washington Street at the planned point of access/egress for either site. The factors contributing to this rating are as follows:

- Access and egress would be directly onto Washington Street, which provides good access to/from both Kneeland and Herald Streets, the principal arterials connecting the study area to I-90 and I-93.
- Washington Street traffic flow is two-way in the area of the garage entry/exit, which facilitates direct access and egress.
- A combination of the above results in minimum circulation on the local street system to get to/from the garage.

In contrast, vehicle access is judged to be no better than "fair" for Site 3. Unlike the situation in Sites 1 and 2, garage access and egress under Site 3 would be on a section of Washington Street where traffic flow is one-way only, and the configuration of the nearby street network imposes a circuitous

path of entry upon vehicles which access the garage. In addition, there is frequently traffic congestion on Herald Street in the PM peak period, which would conflict with egress from the garage.

Table 23 also identifies the streets in which the primary garage-related traffic flow impacts for each of the options are anticipated. Garage access/egress and attendant traffic impacts for all three sites are discussed in greater detail in the next section.

The final column of Table 23 identifies the probable alternate land use for each site if it is not developed as a parking garage. The Site 1 parcel is currently designated as institutional use, as the site is partially owned by NEMCH and is within the NEMCH development area. The Option 2 (R3/R3A) site has been planned by the BRA for a 200 to 225-unit mixed income family housing development. Option 3, the SCM Building site, is owned by the Chinatown Consolidated Benevolent Association, from which it is now leased by Teradyne, Inc.

C. TRAFFIC FLOW IMPACTS

In assessing the traffic flow impacts associated with garage operations at each of the alternative sites, several steps were taken. First, peak hour vehicle-trips into and out of the new parking facility were estimated. Then, based on origin-destination patterns derived from the survey, these trips were assigned to the study area traffic network. It should be noted that this analysis conservatively assumed all of the vehicles represent new trips to the study area rather than a combination of new trips and those trips shifted from currently used NEMCH facilities (i.e., Shoppers Garage). In essence, this probably portrays fairly accurately a 1990 roadway condition, although it

possibly overstates NEMCH's contribution to the traffic volume levels. Realistically, if NEMCH ends its leases with the owners of the Herald or Shoppers Garages, the spaces will most likely be used by someone else, at least in the short term. As a result, simply by using the new parking facility as "replacement" parking does not ensure that "no-change" in area roadway volumes will occur.

With this understanding and the conservative NEMCH impact assumption, the evaluation of traffic flow concentrated in two areas:

-- traffic volume changes, and
-- level of service analysis.

The first criterion evaluated attempts to address the impact from the perspective of the neighborhood. As described earlier in the report, the character of the street can be described in terms of traffic volume levels. Assessing the impact on roadway traffic volumes would identify any change in character.

The level of service analysis, a standard traffic engineering analysis tool, was described earlier in the report as well. this type of analysis identifies the roadway condition from the perspective of the motorist.

1. Garage-Related Trip Generation

Vanasse/Hangen has estimated, on the basis of data for current NEMCH garage operations, that the peak hours of garage-related traffic flow will be 8:00 to 9:00 AM and 5:00 to 6:00 PM, during which times combined entry and exit volumes will be 236 and 327 vehicles, respectively. These represent upper-bound traffic volume estimates for an 850-space facility. For the purposes of analysis, a worst case scenario is assumed under

which all garage-related traffic is considered to be new to the study area, representing a net increase over and above projected 1990 background traffic volumes. As previously described, it is in fact likely that some of the projected garage-related traffic will result from a shift of traffic away from other sections of the study area, in which case the net increase in study area traffic would be lower, and traffic conditions in those other areas would improve, relative to the conditions presented in the following analysis. The breakdown of the total peak hour volumes by entry and exit is as follows:

	Entry	Exit	Total
8:00-9:00 AM	221	15	236
5:00-6:00 PM	53	274	327

For all three site options, garage entry/exit has been assumed to be on Washington Street.

2. Trip Distribution/Street Assignment

Figures 14 through 20 illustrate the traffic flow patterns of vehicles entering and exiting each of the three site options. In developing these flow patterns, the regional distribution of NEMCH-related trip origins was determined, and trips to and from NEMCH were assigned to the regional and local study area highway network, based on access conditions (i.e., circulation system, travel time) between the hospital and individual points of origin/destination. The origin/destination information was obtained through the questionnaire survey conducted for this study, as described earlier in Section I.

These data indicated that hospital-related trips by major area were as follows:

- Core - 39%
- North - 24%
- Northwest - 5%

- West - 15%
- South - 17%

Traffic flow patterns to and from are described below, and the areas of greatest impact are identified.

- Site 1

Based on preliminary analysis and discussions with the BRA and Chinatown community representatives, two alternative routing scenarios were developed for Site 1. These two alternatives define the range of potential impacts which could be expected if a garage were constructed at the Site 1 site. In essence, they represent a sensitivity analysis for travel patterns to/from Site 1.

Alternative 1-a. Under the first scenario, labeled Site 1-a, access to the garage, as illustrated in Figure 14, would be predominantly as follows:

-- Kneeland - 52% - (westbound) → Washington (southbound) → Garage

-- Herald -24% - (westbound) → Washington (northbound) → Garage

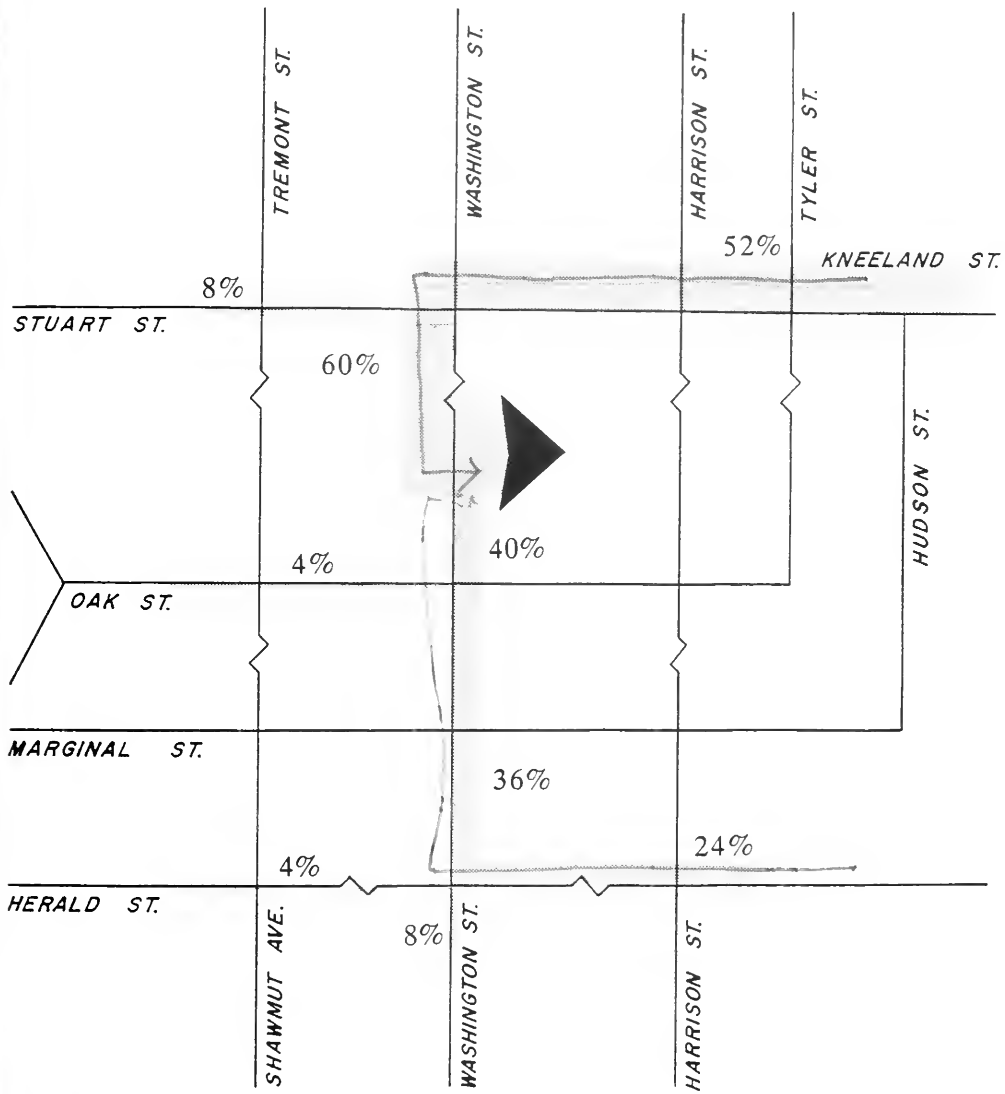
Relatively minor flows are forecast on Oak Street (to the west of Washington) and Stuart Street. All I-90 and I-93 NEMCH-related traffic would follow the above flow pattern. Egress would predominantly follow three routes within the study area (Figure 15):

-- Garage → Washington -24% - (NB) → Kneeland (WB)

-- Garage → Washington -24% - (SB) → Oak (WB)
Harrison (SB) → Herald (WB)

-- Garage → Washington -40% - (SB) → Marginal (EB)

Alternative 1-b. Traffic accessing the garage from Kneeland Street would divide between Hudson Street and Washington Street under this scenario. Although NEMCH-bound motorists exiting



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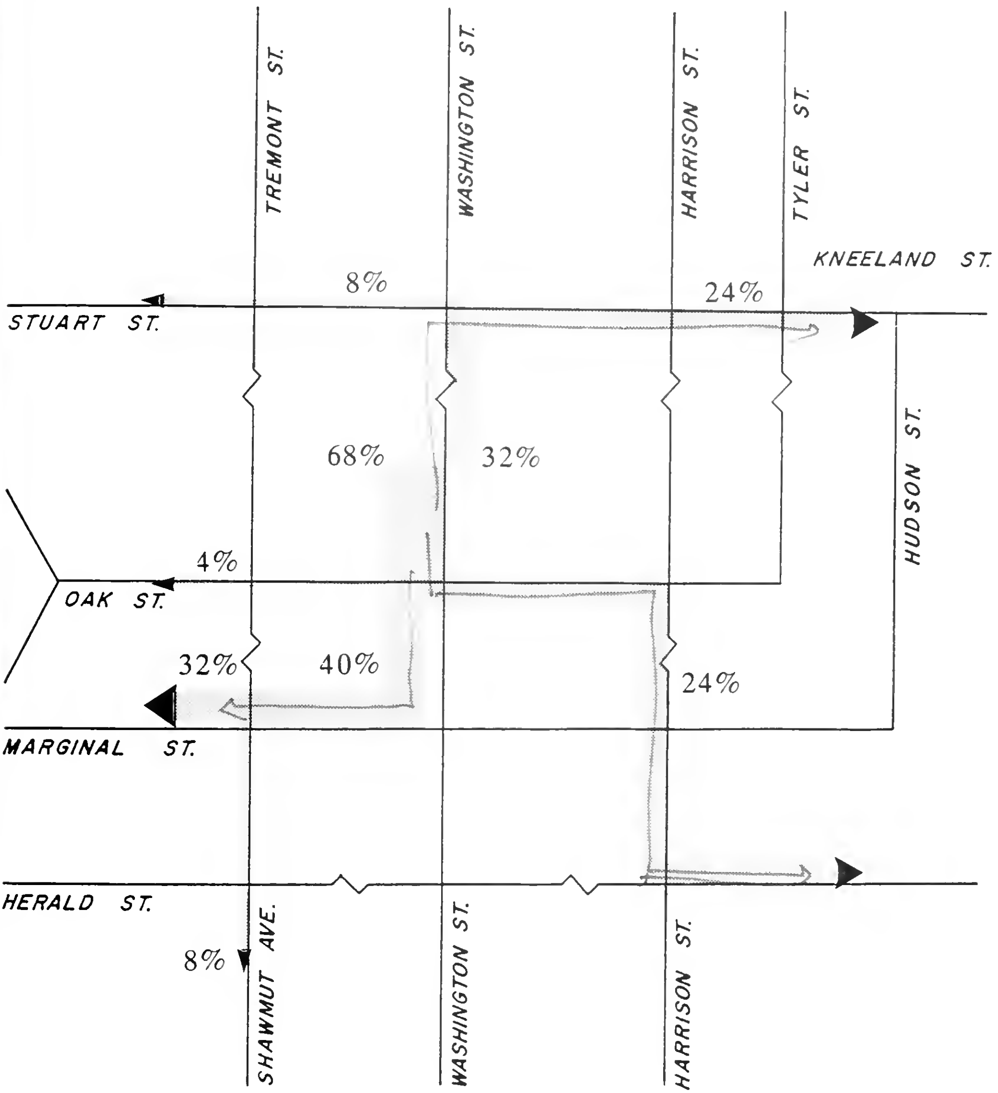
Trip Distribution
Enter
Option 1

Not to Scale

Fig. 14



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Not to Scale

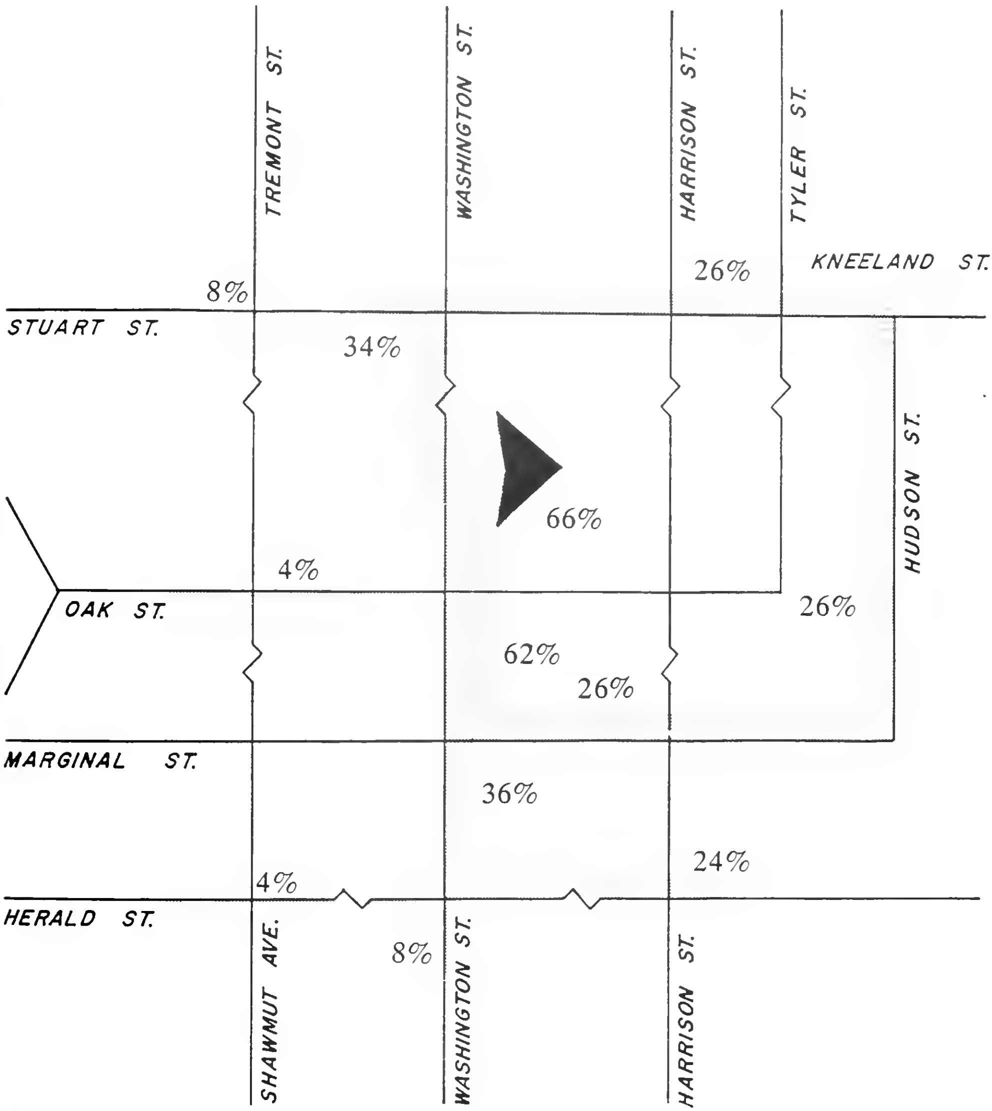
Trip Distribution
Exit
Option 1

Fig. 15

I-90 or I-93 at Kneeland Street would appear to find the Kneeland Street to Washington Street more direct (particularly for Site 1), there is the possibility of some traffic evading the Kneeland Street/Washington Street intersection by using Hudson Street and Marginal Street. It is difficult to accurately estimate the amount of bypass traffic as it is largely dependent on the level of congestion on Kneeland Street. Observations indicate that there are twice the number of left turns onto Washington Street versus Hudson Street. Motorists using Hudson Street to access Site 1 would have to travel to Marginal Street and through two signals along Washington Street before making a right turn into the facility. Based on existing AM peak hour volumes along, a 67/33 percent split on Washington and Hudson, respectively, would appear to be likely. This would mean that 35 percent of the NEMCH trips would travel Kneeland to Washington while 17 percent would travel via Hudson Street. In addition, travel time data indicate that Alternative Route No. 1 takes approximately 2 to 2-1/2 minutes while Route No. 2 takes approximately 4 minutes. This is primarily due to the signal timing plans used throughout the study area network. Combining observed volume data and travel time information, one could estimate a range of Kneeland Street use versus Hudson Street use from 100/0 to 60/40. The sensitivity analysis presented herein assumes a 50/50 split as a worst case condition for bypass traffic.

<u>Access</u> (three predominant flows Figure 16):

-- Kneeland (WB) - 26% → Washington (SB) → Garage
-- Kneeland (WB) - 26% → Hudson (SB) → Marginal (WB) Washington (NB) → Garage
-- Herald (WB) - 24% → Washington (NB) → Garage



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Trip Distribution
Enter
Option 1b

Not to Scale

Fig. 16

→ Fig 16a

Egress (four predominant flows):

-- Garage → 12% → Washington (NB) → Kneeland (EB)

-- Garage → 12% → Washington (SB) → Oak (EB) → Tyler (NB) Kneeland (WB)

-- Garage → 24% → Washington (SB) → Oak (EB) → Harrison (SB) Herald (EB)

-- Garage → 44% → Washington (SB) → Marginal (WB)

Compared to Alternative Route No. 1-a, traffic is somewhat more dispersed. While there is some traffic flow on Hudson Street by vehicles accessing the garage, the volume of traffic is relatively low, as will be discussed at a further point in greater detail. Egress traffic on Oak Street is higher than under Alternative Route No. 1-a because once again more frequent use of the alternate route to Kneeland Street is assumed, under an analagous assumption to that applied in the AM period. In the PM period, 50 percent of the garage traffic routed to I-93 via Kneeland is assigned to Oak Street. This traffic would be required to turn left out of the garage onto Washington and left again onto Oak.

Exit 1-b

- **Site 2**

Access (Figure 17; four predominant flows):

-- Kneeland - (WB) - 18% → Washington (SB) → Garage

-- Kneeland - (WB) - 17% → Harrison (SB) → Marginal (WB) Washington (NB) → Garage

-- Kneeland - (WB) - 17% → Hudson (SB) → Marginal (WB) Washington (WB) → Garage

-- Herald - (WB) - 24% → Washington (NB) → Garage

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Not to Scale

Trip Distribution Enter Option 2

Fig. 17

Egress (Figure 18; three predominant flows)

-- Garage → Washington - (NB) - 12% → Kneeland (EB)

-- Garage → Washington - (SB) - 24% → Oak (EB)
   Harrison (SB) → Herald (EB)

-- Garage → Washington (SB) → Marginal - 44% - (WB)

Compared to either of the Site 1 routing scenarios, a greater proportion of Site 2 traffic would tend to access the facility via Hudson Street and egress via Oak and Harrison Streets.

- Site 3

Site 3 traffic flow patterns will likely differ substantially from those associated with Sites 1 and 2 because it is located in a different section of the study area. As noted previously, Washington Street traffic flow is one-way (northbound) at the SCM site. Virtually all traffic would have to access the site by traveling in a loop configuration east or west on Herald, south on lower Harrison, then west on Mullins Way, and then north on Washington. Two alternative flow patterns have been analyzed, as in the cast of Site 1. The first pattern, labeled 3-b, represents the most direct routings to and from the garage, as shown below and illustrated in Figures 19 and 20.

Access:

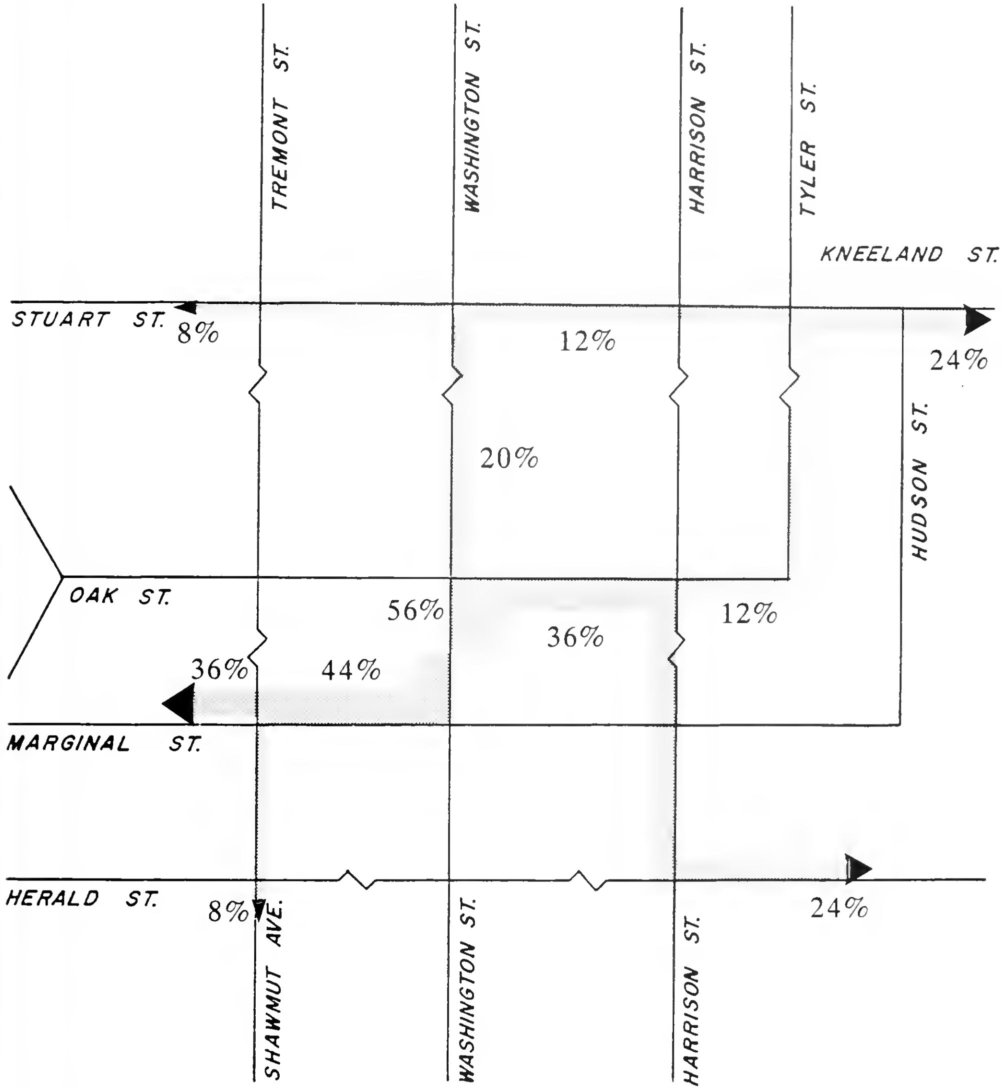
-- Herald (EB - 12% - and WB - 76%) → Harrison (SB) →
   Mullins Way (WB) → Washington (NB) → Garage

Egress:

-- Garage → Washington (NB) - 48% → Herald (EB)

-- Garage → Washington (NB) - 36% → Marginal (WB)

It should be noted that this site essentially confines traffic to Herald, Washington, and Marginal Streets, in areas that are not residential. An alternative flow pattern scenario was developed to account for the likelihood that some traffic would use local streets in accessing the garage from I-93, north of the



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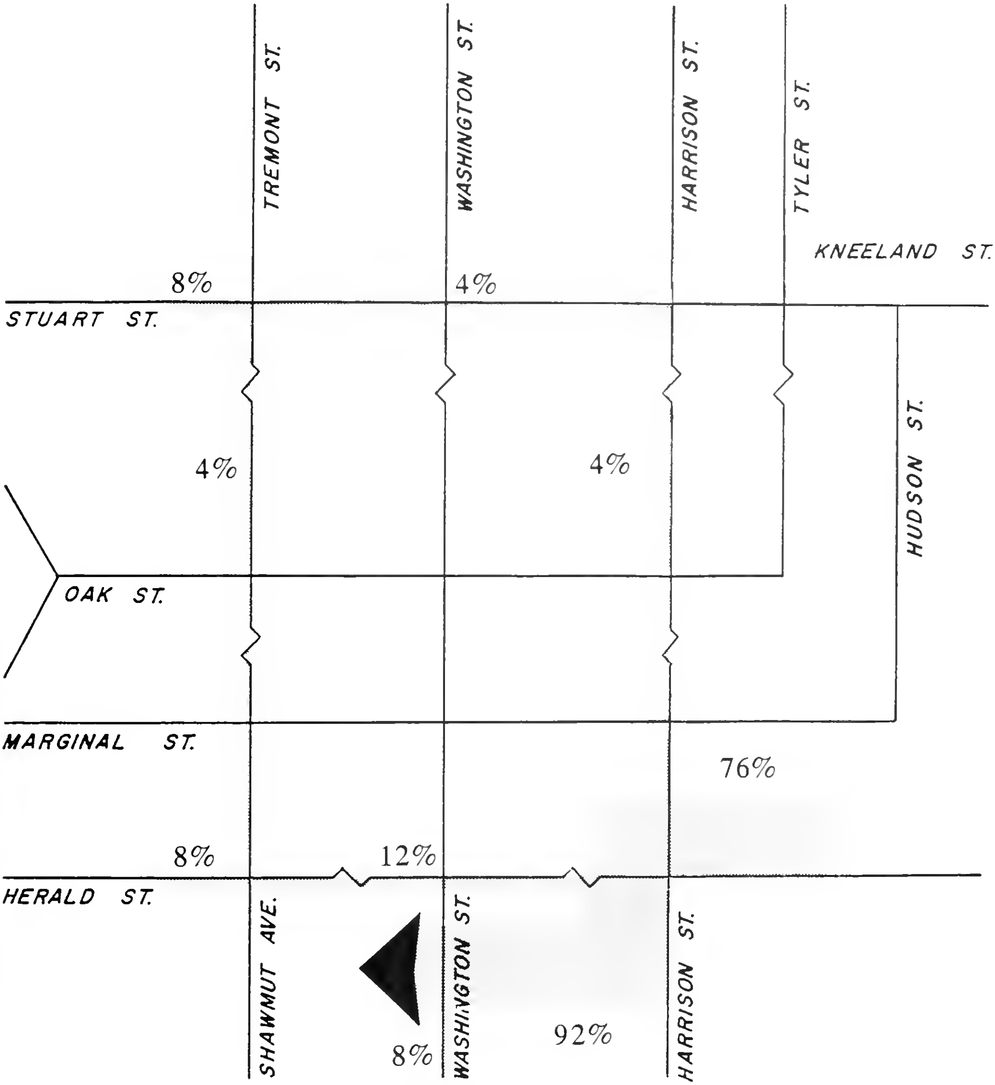
Trip Distribution
Exit
Option 2

Not to Scale

Fig. 18



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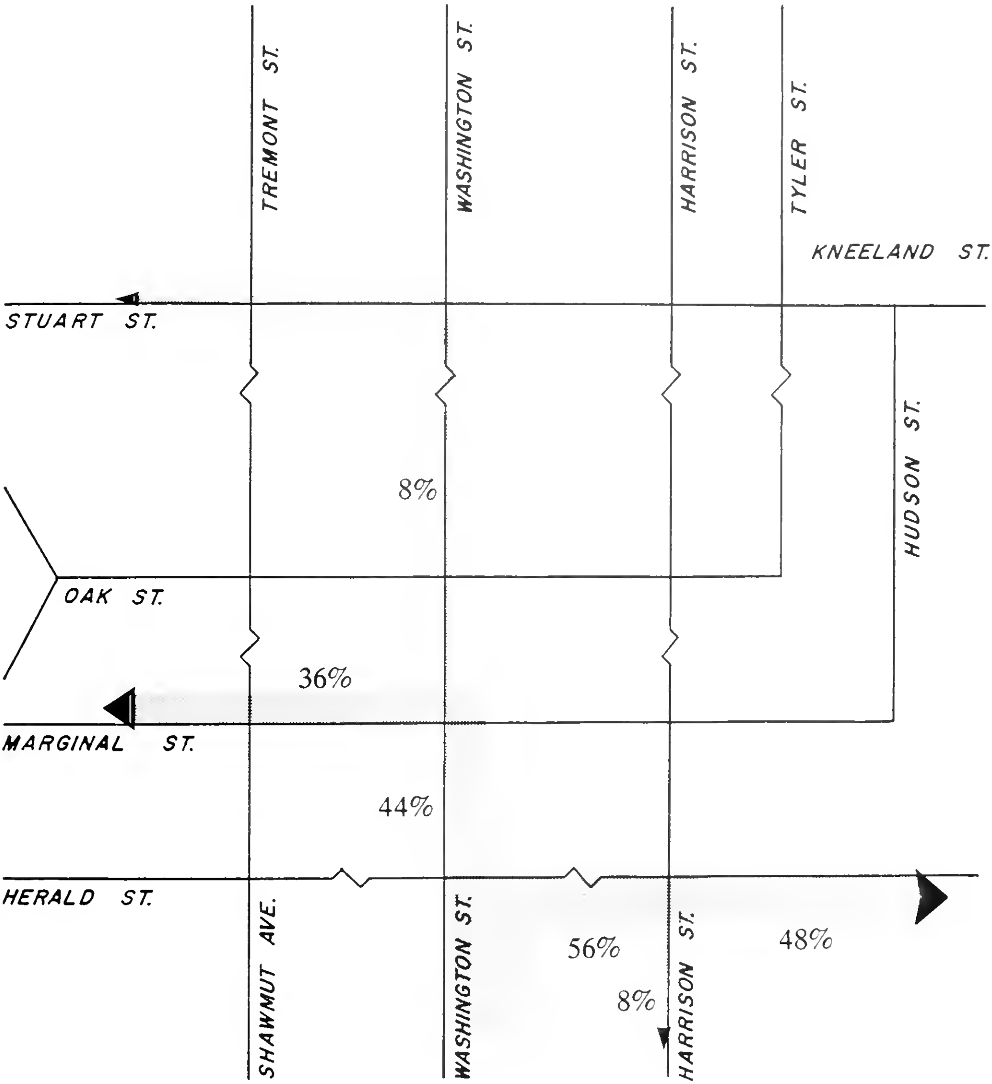
Trip Distribution
Enter
Option 3

Not to Scale

Fig. 19



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Trip Distribution
Exit
Option 3

Not to Scale

Fig. 20

study area, and the Massachusetts Turnpike. The use of local streets would result from drivers seeking to avoid delays on Herald Street and the Turnpike ramp. The 3-a alternative routing pattern is as follows:

Access:

-- Kneeland (WB) - 13% → Harrison (SB) → Mullins Way (WB) Washington (NB) → Garage

-- Kneeland (WB) - 13% Hudson (SB) → Harrison (SB) Mullins Way (WB) → Washington (NB) → Garage

3. Traffic Volumes

The estimated traffic volume networks under each alternative site are shown in Figures 21 through 26. These data are also summarized in Table 24 for key roadway segments in the study area, and discussed below.

The roadway segments that were included in the table show most clearly the relative impacts of the alternative garage locations. In terms of absolute magnitude, the impacts associated with all three sites tend to be greatest on the major study area arterials, including Washington Street. The following roadway segments were included in the table, however, not because they experience the most severe traffic impacts in absolute terms, but because they are primarily local-serving streets in residential areas, which are likely to be most sensitive to any increases in traffic, from the standpoint of community impacts:

- Oak Street between Washington and Harrison Streets
- Harrison Street between Oak and Marginal Streets
- Hudson Street between Kneeland and Marginal Streets

→ Diagram distinguish btw option 3.b for Opts 1, 3

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1990 Option 1
A.M. Peak Hour Traffic Volumes

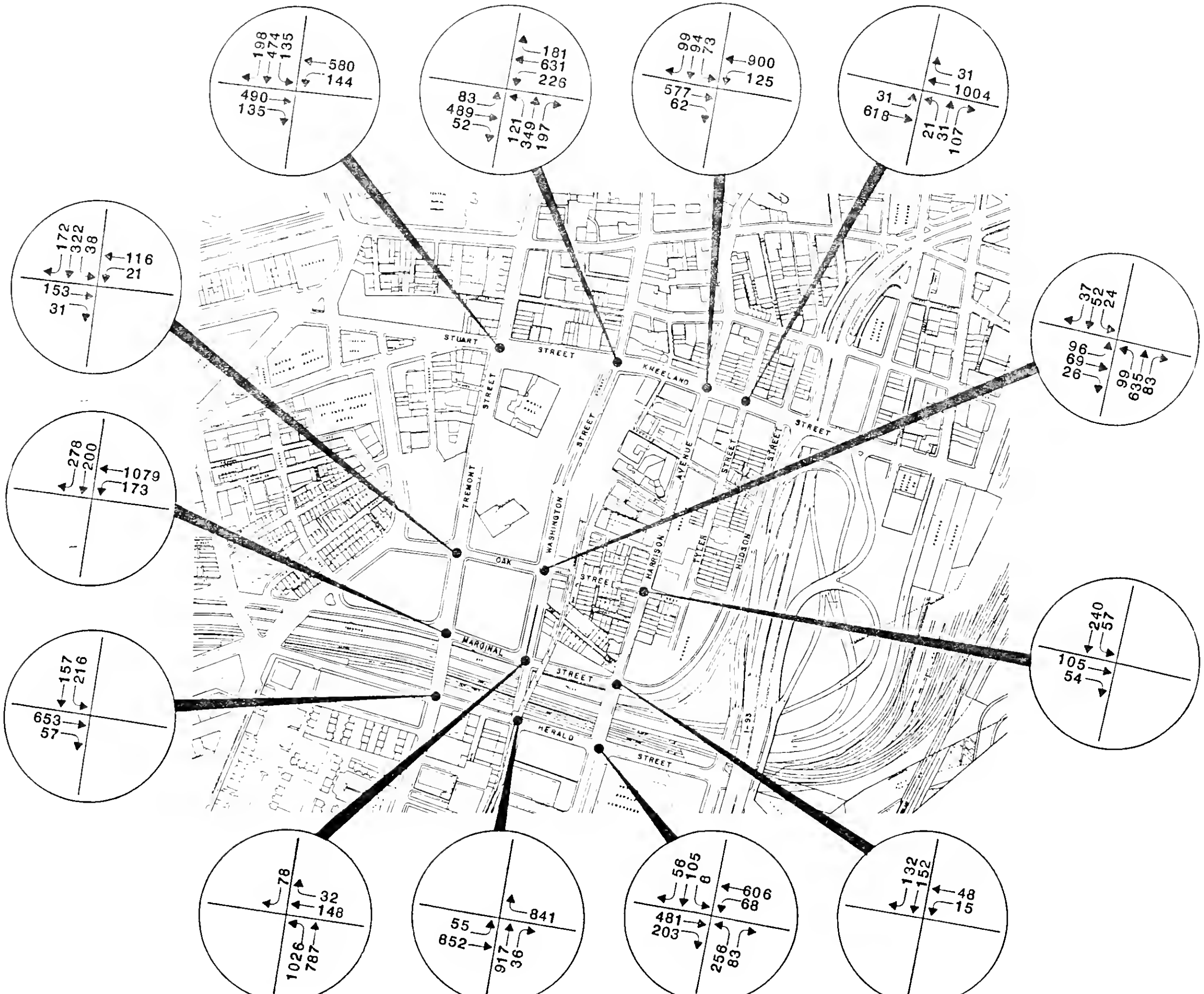

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Fig. 21

1990 Option 1
P.M. Peak Hour
Traffic Volumes

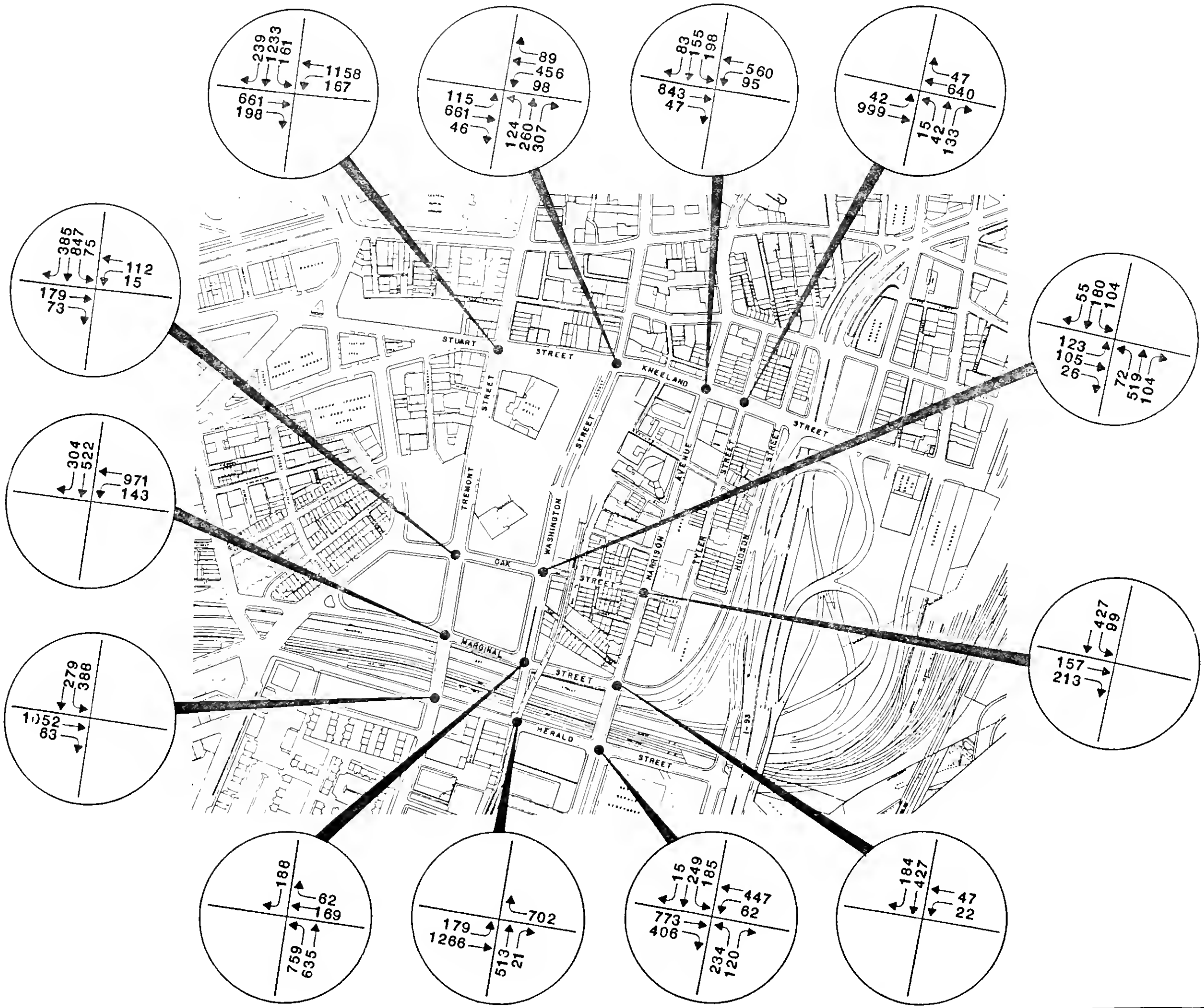

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Fig. 22

1990 Option 2 A.M. Peak Hour Traffic Volumes

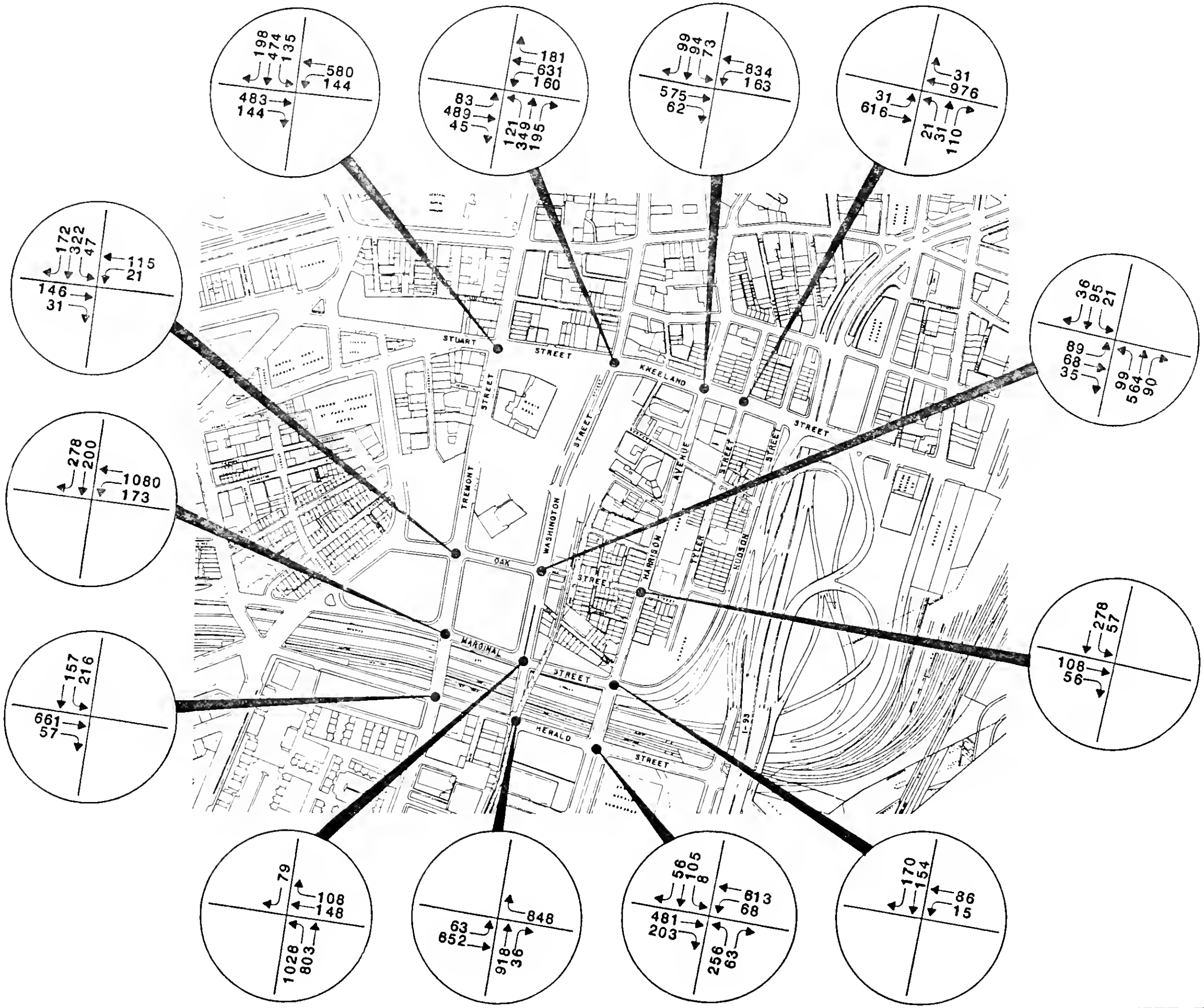

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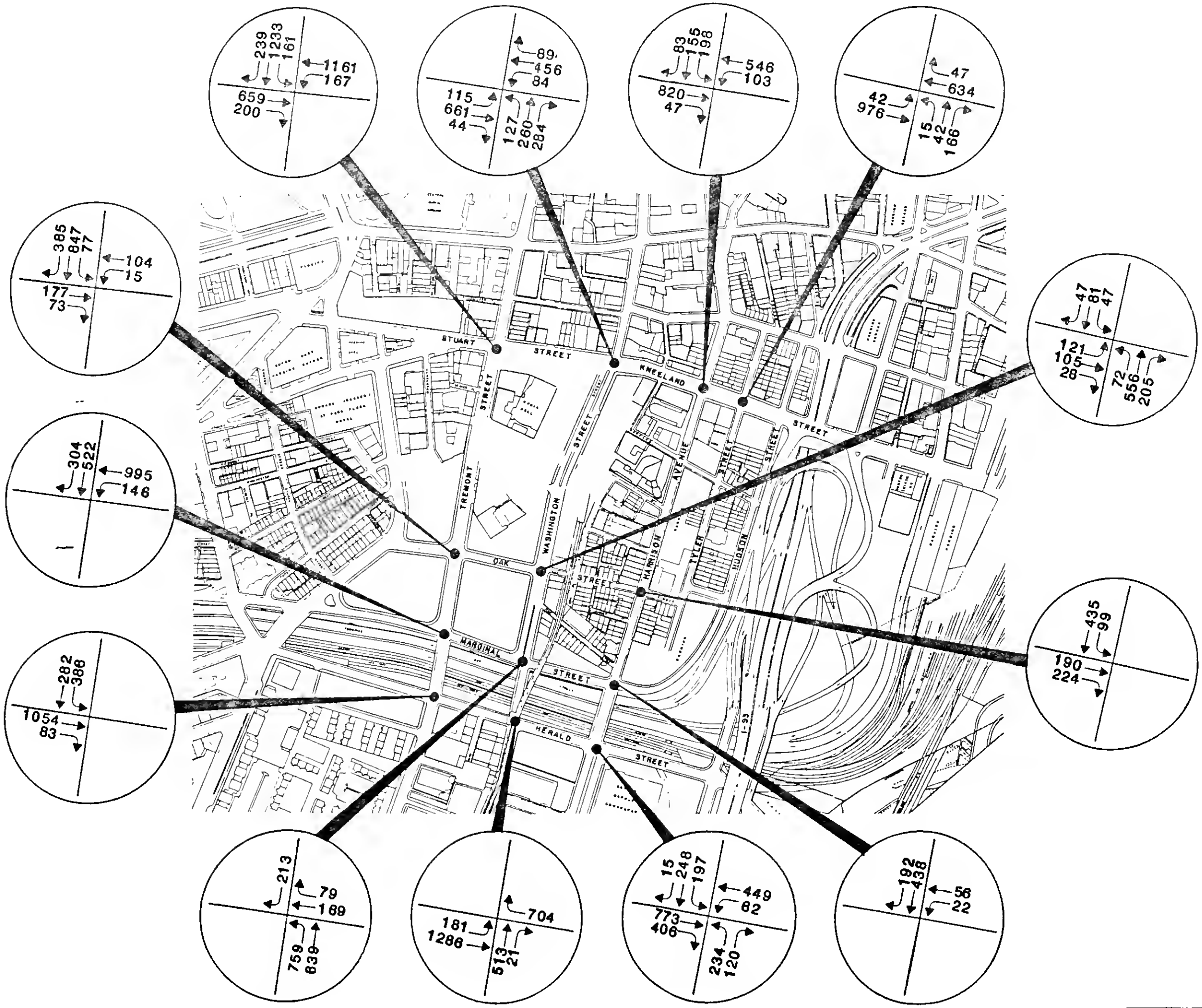
Fig. 23



1990 Option 2 P.M. Peak Hour Traffic Volumes

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Fig. 24

1990 Option 3 A.M. Peak Hour Traffic Volumes

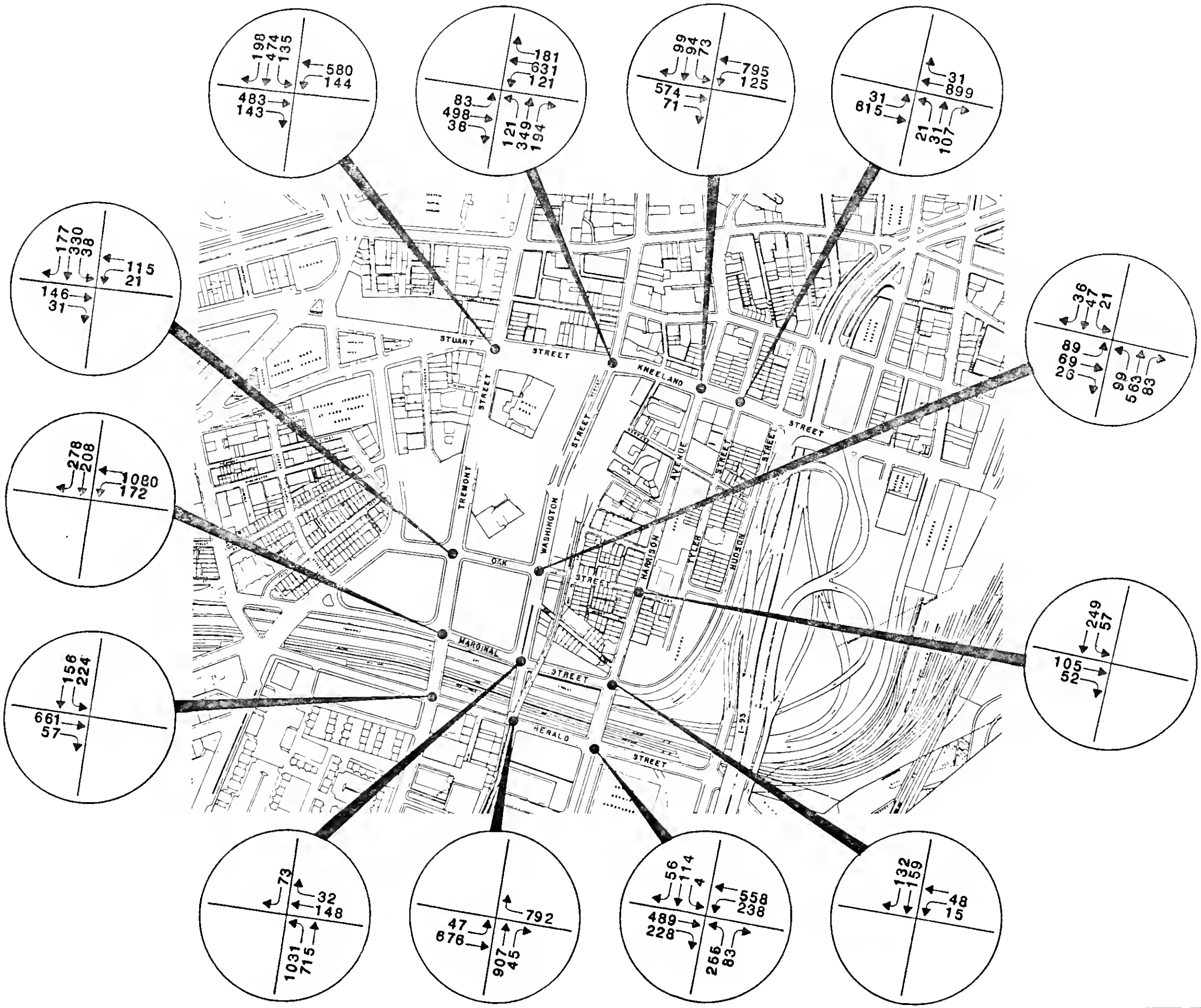

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Fig. 25

1990 Option 3
P.M. Peak Hour
Traffic Volumes

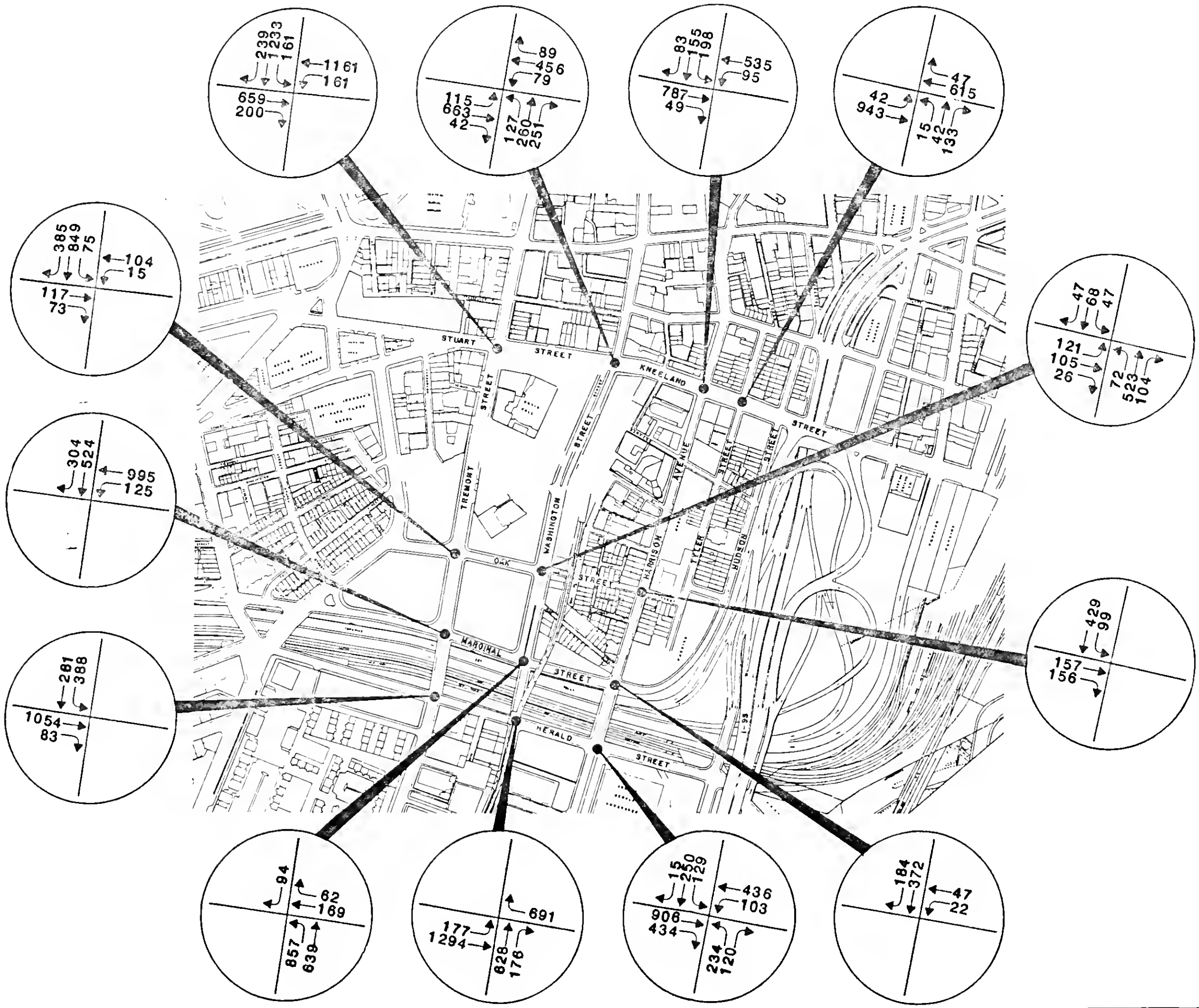

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Fig. 26

routing, 1-b, was developed in recognition of the observed tendency of some vehicles to access Site 1 from Kneeland Street in the northeast corner of the study area, via Hudson and Marginal Street, therefore bypassing the Kneeland Street/Washington Street intersection. This is a more circuitous maneuver than the Kneeland-Washington route, requiring traffic to travel a longer distance and through an additional intersection. Overall traffic flow conditions at all intersections along Kneeland Street, particularly during the AM peak hour, have been generally projected to operate at acceptable levels of service which would tend to discourage a large number of vehicles from accessing Site 1 via Hudson and Marginal Streets. As discussed earlier, a maximum of 50 percent of all traffic from the north and west accessing the site was assumed to use the Hudson-Marginal-Washington route. This traffic pattern has been incorporated into Scenario 1-b.

As would be expected, traffic impacts on Kneeland Street would be less pronounced under Scenario 1-b than Scenario 1-a. In the AM peak hour, only 55 more vehicles are projected to use Kneeland Street, between Washington and Harrison, under Scenario 1-b than in the 1990 Base Case (i.e., No-Build). This compares with an estimated increase of 108 vehicles on this street segment under Scenario 1-a, as noted previously. Under this scenario, it is estimated, however, that up to 52 vehicle-trips would be added to Hudson Street in the AM peak hour, relative to 1990 baseline conditions. In the PM peak hour, the principal differences between Scenario 1-a and Scenario 1-b are that the impact on Kneeland Street would be reduced by one-half under the latter scenario, while a total of 85 vehicle-trips would be added to Oak Street, compared to 57 vehicle-trips under Scenario 1-a.

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• **Site 2**

Site 2 (R3/R3A parcel) is located in close proximity to Site 1. As a result, projected traffic flow changes for Site 1 and Site 2 are similar, particularly when the comparison is based on the alternative routing for Site 1, 1-b. The principal differences between the two sites are as follows:

- The net increase in PM peak hour traffic volumes on Oak Street rises from 57 (Site 1-a) or 85 (Site 1-b) vehicles to 101 vehicles (Site 2).

- The net increase in PM peak hour traffic on Harrison Avenue rises from 57 (Sites 1-a and 1-b) to 76 vehicles (Site 2).

- The combined net increase in AM peak hour traffic volumes on Hudson Street and Harrison Avenue rises from 2 (Site 1-a) or 55 (Site 1-b) vehicles to 99 vehicles (Site 2).

- The net increase in both AM and PM traffic volumes on Kneeland Street is lower with Site 2, due to more dispersion of traffic onto Hudson Street, Harrison Avenue and Oak Street.

The reason projected PM peak hour impacts are higher on Oak and Harrison Streets in the case with Site 2 is that vehicles exiting the garage could turn right out of the facility and right only Oak Street. In contrast, with Site 1, two left turns, a more difficult and time consuming maneuver, would be required.

• Site 3

Both AM and PM peak hour traffic impacts for Site 3 are generally expected to be most concentrated on Herald Street. However, during the AM peak hour, some variation to this would occur when traffic flow increases may occur on the more local neighborhood streets.

As a result, two alternative routing scenarios were analyzed for Site 3, as for Site 1. In Scenario 3-a, traffic was assigned on the most direct routes to and from the garage. Traffic volumes under this scenario increased on Herald Street between Harrison and Albany Streets by 178 vehicles, to a total of 1,372 vehicles, in the AM peak period, and by 174 vehicles, to a total of 1,694 vehicles, in the PM period.

Most of the estimated traffic increase on Herald Street in the AM period would be westbound, turning left onto lower Harrison, where traffic volumes are already high. It is likely that some of the traffic accessing the garage from the north via I-93 and the west via the Massachusetts Turnpike would seek alternate routes, to avoid this turn. In addition, when the Turnpike ramp is queued with vehicles preventing easy access to Albany Street, motorists may exit to the local network via Kneeland Street. Scenario 3-b routings were diagrammed earlier.

Garage-related traffic would use Harrison Avenue, between Kneeland and Herald, and Hudson Street under this scenario labeled 3-b. To measure the impacts of this scenario, sensitivity analysis was conducted assuming that 50 percent of the traffic accessing the garage from the north, via I-93, and from

?? 3-b diagram.

the west, via the Turnpike, used the Scenario 3-b alternative routings. The resulting traffic volume impacts were as follows:

- The net increase in AM and PM volumes on Herald Street were 120 and 160 vehicles, respectively, which represents a reduction in impacts relative to Scenario 3-a, of 58 vehicles in the AM and 14 vehicles in the PM. The decreases on Herald Street result in increases on Harrison and Hudson Streets.

- In the AM peak hour there would be an increase of 29 vehicles on Hudson Street and 28 vehicles on Harrison Street between Oak and Marginal. In the PM peak hour, impacts remain minimal on all streets except Herald, Washington and Marginal.

4. Character of Street

Based on the traffic volume impacts of the alternative facility sites, the effects on the character of the streets were identified. As described earlier in the report, the neighborhood streets can be classified into three groups based on level of traffic volume as follows:

-- 0-2,000 vehicles per day - light volume roadway
-- 2,000-10,000 vehicles per day - medium volume roadway
-- above 10,000 vehicles per day - heavy volume roadway

The evaluation of the three alternatives sites focused on identifying any change in the character of the neighborhood streets from the existing and 1990 base conditions with respect to the above criteria.

As can be seen from the traffic volume data presented in Table 25, it is not anticipated that street character will change substantially from current conditions, again based on the category levels defined above. Although each street included in the

5. Level of Service/Capacity

The impacts of the three major site options on study area traffic operations have been examined through level of service analysis. The procedures and criteria were described previously in this report. The results of the analysis are presented in Table 26. Background "1990 No-Build" conditions are shown in Column 3. The roadway operation impacts of alternative facility Sites 1, 2, and 3 can be assessed by comparing the LOS ratings as well as the volume-to-capacity ratios for each of these alternatives against the projected conditions for the 1990 No-Build case.

- Site 1

Under the routing scenario 1-a, the only significant impacts on traffic operations associated with Site 1 are AM peak hour decreases in LOS from "A" to "B" at the Kneeland/Harrison intersection, and "B" to "C" at the Kneeland/Washington intersection. The V/C ratios at these intersections change from 0.56 in 1990 base conditions to 0.69, and 0.71 in 1990 base conditions to 0.77, respectively. These are essentially worst case forecasts for Site 1 with respect to Kneeland Street, since this routing scenario assumes all garage traffic from I-93 at Kneeland Street is routed through on Kneeland to Washington Street. Under routing scenario 1-b, some of this traffic is assumed to divert to Hudson Street and bypass the Kneeland Street/Washington Street intersection.

Other intersections are not expected to experience changes in operating conditions as a result of the project.

TABLE 26
INTERSECTION LEVEL OF SERVICE ANALYSIS

Location	Existing Conditions				1990 No-Build				1990 Build Option 1				1990 Build Option 2				1990 Build Option 3			
	AM		PM		AM		PM		AM		PM		AM		PM		AM		PM	
	V/C*	LOS**	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS
Kneeland St./ Tyler St.	-	A	-	A	0.51	A	0.57	A	0.56	A	0.59	A	0.55	A	0.58	A	0.51	A	0.57	A
Kneeland St./ Harrison Ave.	-	A	-	A	0.56	A	0.57	A	0.60	B	0.59	A	0.62	B	0.59	A	0.57	A	0.58	A
Kneeland St./ Washington St.	-	B	-	B	0.71	B	0.70	B	0.77	C	0.79	C	0.73	B	0.75	C	0.71	B	0.71	B
Stuart St./ Tremont St.	-	A	1.06	E	0.62	B	1.10	E	0.62	B	1.10	E	0.62	B	1.10	E	0.62	B	1.10	E
Oak St./ Harrison Ave.	-	A	-	A	***	A	***	A	***	A	***	A	***	A	***	B	***	A	***	A
Oak St./ Washington St.	-	A	-	A	0.38	A	0.43	A	0.42	A	0.47	A	0.39	A	0.48	A	0.39	A	0.43	A
Oak St./ Tremont St.	-	A	-	A	0.25	A	0.47	A	0.26	A	0.47	A	0.25	A	0.47	A	0.25	A	0.47	A
Marginal St./ Harrison Ave.	-	A	-	A	0.14	A	0.23	A	0.14	A	0.23	A	0.18	A	0.26	A	0.14	A	0.22	A
Marginal St./ Washington St.	-	A	-	A	0.46	A	0.40	A	0.48	A	0.43	A	0.51	A	0.44	A	0.46	A	0.43	A
Marginal St./ Shawmut Ave.	-	A	-	A	0.46	A	0.43	A	0.46	A	0.45	A	0.46	A	0.46	A	0.46	A	0.43	A
Herald St./ Harrison Ave.	0.55	B	0.78	C	0.58	B	0.87	C	0.60	B	0.87	C	0.60	B	0.87	C	0.78	C	1.25	E
Herald St./ Washington St.	-	A	-	A	0.63	B	0.61	B	0.66	B	0.61	B	0.67	B	0.61	B	0.64	B	0.70	C
Herald St./ Shawmut Ave.	-	A	-	A	0.32	A	0.52	A	0.32	A	0.53	A	0.32	A	0.53	A	0.32	A	0.52	A

* V/C = Volume-to-capacity analysis.
*** LOS = Level of service.
**** V/C not calculated for unsignalized intersection.

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• Site 2

Site 2 operational impacts primarily consist of the following reductions in level of service when compared to 1990 No-Build.

	1990 No-Build	Site 2
Kneeland/Harrison (AM)	A	B
Kneeland/Washington (PM)	B	C
Oak/Harrison (PM)	A	B

Changes in V/C ratios at the Kneeland/Harrison (AM) and Kneeland/ Washington (PM) intersections are approximately 11 and 7 percent, respectively. Changes in V/C ratios at other intersections are negligible, except at Oak/Washington (AM) and on Marginal Street at the Washington and Shawmut Avenue intersections, where the PM V/C ratios increase by an average of approximately 10 percent. Generally, intersections would continue to operate at acceptable or good levels of service.

• Site 3

With Site 3, level of service impacts would be generally concentrated on Herald Street. In the AM peak hour, level of service would decline from "B" to "C" at the Herald/Harrison intersection. The left-turn to Harrison, however, would operate at LOS E with motorists experiencing relaltively long delays. In the PM peak hour, Herald/Harrison would experience a reduction in level of service from "C" to "E", and level of service would decline from "B" to "C" at the Herald/Washington Street intersection as 80 to 100 percent garage-related traffic would proceed through these intersections. As discussed previously, the Herald Street traffic stream currently experiences significant PM peak hour traffic delays, which are only partly reflected in the level of service measurements. Garage operations at Site 3 would

aggravate existing and No-Build conditions. The level of congestion at the Herald/Harrison intersection increases by approximately 40 percent as reflected by the volume-to-capacity ratio change from the No-Build condition. It should also be noted that the MBTA is currently considering plans to operate a light rail vehicle (LRV) transit or electric bus line on Washington Street through the Washington/Herald Street intersection. If the MBTA does decide in favor of either service, garage access/egress may be impaired, perhaps to the point where the feasibility of Site 3 becomes questionable. Traffic operational impacts at intersections on all roadways other than Herald Street would be minimal.

6 Traffic Analysis Summary

The analysis presented in this section has assessed the traffic impacts associated with three alternative parking garage sites, in terms of changes in traffic volumes, traffic flow and quality of vehicle access. The results of this analysis can be summarized as follows.

- Changes in traffic volumes under any of the site options will not change the fundamental character of any streets in the project area. The street segments which are most sensitive to traffic impacts from the standpoint of the local community are Oak Street, Harrison Avenue between Oak and Marginal, and Hudson. Under the Site 2 option, the maximum AM peak impact on these three streets would be on Hudson where up to 52 vehicles might be added to the traffic stream, although the probable impact is substantially lower. In the PM period, 57-85 vehicles would be added to Oak Street and 57 vehicles would be added to Harrison Avenue in the case of Site 1. Changes in traffic volumes would be otherwise confined essentially to Kneeland and Washington; Harrison and Marginal

Streets. Under the Site 2 option, impacts would be similar, although PM peak traffic increases on Oak and Harrison would be increase to 101 vehicles and 76 vehicles, respectively. In the case of Site 3, which is farther from the residential areas north of the Turnpike, traffic changes on local streets would likely be minimal, since garage traffic would essentially be confined to Herald, Marginal and Washington Streets. However, as stated earlier, depending on operating conditions of the regional system and the level of congestion at the Herald/Harrison Street intersection, motorists to/from the north and west could divert to the more local streets, specifically Hudson Street and Harrison Avenue.

- Changes in intersection operations will be minor in the case of Sites 1 and 2. The most significant change under the Site 1 option will be a decline in level of service from "B" to "C" at the Kneeland/Washington intersection in the AM and PM peak hours. Potential mitigation measures to reduce even this relatively small impact are discussed later in this report. In the case of Site 2, garage-related traffic flows will be slightly more diffuse than under the Site 2 option, and the impact on the Kneeland/Washington intersection somewhat reduced, although in the PM peak hour, a level of service change from "B" to "C" is estimated to occur.

- The Site 3 option will result in substantial impacts on Herald Street traffic operations. In the AM peak hour, level of service at the Herald/Harrison intersection will decline from"B" to "C". However, the left-turn movements from Herald Street to Harrison Avenue will operate at LOS "E". During the PM peak hour, overall intersection level of service will decline from "C" to "E" at the Herald/

Harrison intersection and "B" to "C" at the Herald/Washington intersection. If an MBTA Orange Line replacement service is routed along Washington Street through the Herald Street intersection, as appears probable, traffic operations at the intersection are likely to be further impaired.

- Vehicle access at Sites 1 and 2 will be good, assuming a median break is provided on Washington Street at the garage entrance/exit. Vehicles will be able to approach the garage from both the north and south directly on Washington Street. In the absence of a median break, however, Washington Street would function in essence as a one-way street in regard to garage entry/exit. This would increase the circuitousness of access to and from the garage and result in higher volumes on the local streets.

- The Site 3 entrance/exit would actually be located on a one-way section of Washington Street, and access to the garage would be by a circuitous route, particularly for vehicles approaching the garage from the west.

D. PEDESTRIAN IMPACTS

As discussed previously, it is estimated that during the peak hour of garage operations, 236 vehicles would enter and exit a new 850-space employee parking facility. With an average occupancy rate of 1.2 persons per vehicle, this translates into a total of 283 persons entering and exiting the facility during the peak hour. If evenly distributed throughout the hour, the combined rate of arrival and departure would be five persons per minute. Various factors, such as waiting for garage elevators, will tend to bunch pedestrians into platoons. Even accounting

for this tendency for flows to be uneven, total pedestrian volumes will not be of sufficient magnitude to cause crowding on sidewalks, or to generate significant conflicts with vehicle traffic on Washington Street.

Since pedestrian flows will quickly disperse upon exiting the garage, any impacts on sidewalks outside the immediate entry/ egress area will be negligible. This is particularly true with Sites 1 and 2. However, a facility on Site 3 would require parkers to walk across Herald Street and either down Harrison or Washington Street. From the standpoint of pedestrians, the walk between Site 3 and the hospital is relatively long, less secure and safe than in the case of Sites 1 and 2.

TRANSPORTATION MANAGEMENT AND MITIGATION MEASURES

*effect of improved transit service

SECTION III

TRANSPORTATION MANAGEMENT AND MITIGATION MEASURES

The magnitude of NEMCH's parking needs, as well as long-term uncertainty regarding the availability of some of its current supply, suggest that options for expanding the NEMCH-controlled parking supply warrant detailed attention. Thus, it has been the focus of the previous discussion to evaluate the traffic-related impacts associated with parking supply options at three locations. Later in this report, air quality and noise impacts of the alternative facility sites are discussed. This section reviews the feasibility and likely impacts of a variety of transportation management measures which also could be of benefit to the hospital and its neighboring community. Some of these would be implemented directly in conjunction with a new garage, and some are independent of supply expansion options. The measures analyzed below are divided into two broad categories: 1) Demand Management, and 2) Traffic Management.

A. DEMAND MANAGEMENT

The purpose of demand management is to reduce the frequency of vehicle travel, chiefly through diversion of low-occupancy vehicle users to alternative high occupancy modes, specifically public transportation and carpools. Current efforts by NEMCH to foster use of transit and ridesharing modes were documented in Section I. Vanasse/Hangen has evaluated potential measures which would attempt to expand upon existing NEMCH demand management programs. The estimated effect and their associated advantages and disadvantages are discussed below.

1. Ridesharing

Employer-based actions to promote ridesharing, or the use of carpools and vanpools, include the following:

- Information and marketing efforts
- Carpool/vanpool matching
- Preferential parking

NEMCH has attempted, through Caravan for Commuters, Inc., to initiate the types of actions identified above. To determine the value of further efforts in this direction, Vanasse/Hangen has analyzed the potential impact of additional ridesharing promotional efforts, in terms of total parking demand.

Ridesharing is typically difficult to coordinate among hospital employees due to several factors including variations in work hours, and the necessity in some cases of having the private vehicle available. Average vehicle occupancy levels are typically low. Also, in hospital settings such as that at NEMCH, where public transportation serves a high percentage of employee trips, ridesharing would serve as an alternative to public transportation as often as driving and as a result have minimal effect on reducing parking demand.

To estimate the magnitude of the potential carpool/vanpool market, Vanasse/Hangen examined results of the Questionnaire Survey to determine how many employees commute to the hospital from the same geographic areas within similar time periods. The number of employees from each community who arrive at the hospital between 7:00 and 9:00 AM, and depart between 4:00 and 8:00 PM, were determined. Individuals in this category could be candidates for ridesharing, because it may be possible to coordinate their commuting schedules and routes. Since broad time intervals were applied in this selection process, however, particularly in

the PM commuting period, the figures generated through this method actually define the outer limits of the potential ride-sharing market. Potential participation in ridesharing programs would be a fraction of this target market. The communities with three or more employee respondents having arrival and destination times within the time intervals specified are shown in Table 27.

Applying the 44.7 percent driver mode share for NEMCH employees to the above total of 277 respondents, and expanding the survey results to the estimated weekday population of 3,800 employees,[6] an upper-bound estimate of the potential ridesharing market emerges, equal to approximately 225 employees. A realistic estimate of the potential ridesharing participation rate for this market would be 20 to 50 percent, or 45 to 113 persons. Assuming an average vehicle occupancy of 2.5 persons among ride-sharing participants, it is estimated that an aggressive ride-sharing matching and promotional effort could reduce total NEMCH parking demand by 27 to 70 spaces per day.

2. MBTA Monthly Pass Distribution

The hospital's method of distributing MBTA passes is to sell them at 100 percent cost at the Head Cashier's Office during the last three working days of each month. Alternatively, or in addition to this system, the hospital could institute an MBTA pass payroll deduction program, in which employees could enroll on a continuous basis. Once each month, the cost of the MBTA

6/ Estimated daily employee driver population is approximately 1,700. Approximately 770 employees who responded to the survey indicated that they are drivers. Expansion factor therefore equals 2.2.

TABLE 27
EMPLOYEES COMMUTING BY
SINGLE OCCUPANT VEHICLES

	Respondents Commuting To/From Hospital During Peak Periods*
Allston/Brighton	18
Dorchester	19
Hyde Park	5
Mattapan	5
Roslindale	7
South Boston	6
West Roxbury	4
Malden	6
Newton	45
Quincy	11
Somerville	5
Jamaica Plain	5
Braintree	6
Brockton	7
Brookline	17
Cambridge	12
Everett	4
Framingham	5
Gloucester	3
Lynn	3
Malden	5
Marblehead	4
Medford	3
Milton	5
Natick	9
Needham	5
Norwell	3
Randolph	3
Sharon	5
Southborough	3
Waltham	6
Watertown	6
Wellesley	7
Weston	7
Weymouth	6
Winchester	3
Winthrop	4
Total	277

* Peak periods defined as: Arrive - 7:00-9:00 AM
Depart - 4:00-8:00 PM.

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pass would be deducted from each subscribing employee's paycheck. MBTA passes would be distributed by the hospital each month to employees enrolled in the program.

Nearly 800 employers throughout Boston and Cambridge have instituted programs of the type described above, with the support of the MBTA's Marketing Department. This system of distribution increases the convenience of purchasing MBTA passes, and serves to ensure more consistent use of public transportation services among employees. The impact of this type of program at the NEMCH, in terms of employee mode choice and frequency of automobile commuting, cannot readily be quantified. The most likely impact, however, is a small increase in the transit mode share. While this result would be beneficial to the hospital, parking demands would remain substantially unchanged.

3. MBTA Monthly Pass Subsidy

An additional measure which could be adopted by the NEMCH would be to subsidize MBTA monthly passes. Depending on the level of subsidy, this measure could induce a measurable impact on employee mode choice. There are, however, a number of serious drawbacks associated with this type of program, as described below.

Expense: Transit pass subsidies could prove to be very costly to the NEMCH, which has nearly 4,000 employees on its payroll. The MBTA Marketing Department reports that only 100 employers have instituted transit pass subsidies as employee benefits.

Effectiveness: Numerous studies have shown that price incentives have a limited although measureable impact on modal choice.[7]

====================

7/ Use of transit services is known to be inelastic with respect to price changes. The long-established Simpson-Curtin "rule of thumb" is that for every 100 percent change in transit fares, a 30 percent change in transit use will result.

In the case of NEMCH, a transit pass subsidy would not be particularly cost-effective, since the vast number of employees who currently use public transportation (approximately 1,400 persons each day) would be eligible for the subsidy, in addition to new transit system users.

Equity: According to the parking service office, parking fees charged at NEMCH-controlled spaces cover the costs of operating the NEMCH parking system. Thus, users of NEMCH parking facilities are not subsidized. It is reasonable to predict that explicit subsidies of transit users could generate pressures to provide equivalent levels of subsidy for other employees who drive their private automobiles.

4. Increase Employee Parking Fees

An alternative to subsidizing transit passes, which would have a similar effect (i.e., a mode shift from auto to transit) at less cost to NEMCH would be to increase parking fees. Employee parking fees, as detailed in Section I, are currently lower than prevailing daily rates in the vicinity of the study area, although they are not necessarily lower than typical employee rates in Downtown Boston, which are often far below commercial rates. A monthly parking pass now costs between $60 and $75 and fees are scheduled to increase systemwide in August of this year, by as much as 33 percent. The scheduled increase could result in a small reduction in employee parking demands ranging from 15 to 35 vehicles. Again, the characteristics of hospitals and their staff schedules and responsibilities can reduce the effectiveness of this option.

Further increases in employee parking rates can be considered by the hospital. A substantial increase, on the order of 100 percent systemwide above current level, could lower total daily employee parking demands by 5 to 10 percent, or 50 to 100 vehicles each day. Most significant is the fact that expensive parking would impair the hospital's ability to attract and keep qualified staff. The NEMCH must compete for employees among the numerous other hospitals in the Boston area, most of which provide more plentiful, lower-priced parking. While parking conditions represent only one factor among many which influence employee workplace decisions, there is little doubt that for many people, non-competitive parking rates would have a negative effect on the image of NEMCH as an employer. Again, it is important to note that the existing rate structure is consistent with that for employee spaces at many other workplaces in the Downtown area. Moreover, since current fees cover the costs of operating the NEMCH parking system, there is little financial justification for substantial rate hikes.

B. TRAFFIC MANAGEMENT

The measures discussed below are not intended to reduce the frequency of automobile travel to and from the hospital, but to reduce any adverse traffic flow impacts associated with NEMCH parking operations, particularly at the new garage facility under consideration. These actions should therefore be viewed as mitigation measures.

1. Control of Garage Entry/Exit

The location of the garage entrance/exit on Washington Street is itself an action intended to reduce traffic and congestion on neighborhood streets. Entry into the garage can be designed to facilitate flow into the facility, which will serve to minimize

any queuing that might otherwise occur on-street. This can be accomplished by providing three entrance/exit lanes, with the middle lane being reversible, which will allow for two lanes of traffic in the direction of heavy flow at all times. Since this will be an employee-only facility, a card reader or pass system would also contribute to maintaining smooth, rapid traffic flow into the garage.

2. Neighborhood Street Management

There are several specific actions that can be undertaken to direct traffic flow onto arterial roadways and minimize the intrusion of hospital-related traffic into neighborhood streets:

- Close Nassau Street: In the event that Site 1 is selected, entry/egress from the garage would be via an extension of Nassau Street onto Washington Street. A recommended measure is to close off the segment of Nassau Street east of the garage from the garage entry/exit to prevent garage traffic from using Harrison Street.

- Prohibition of left turns from Kneeland Street onto Hudson Street in AM commuting period. In connection with Sites 1 and 2, it would be beneficial to prohibit left turns from Kneeland Street onto Hudson Street during the period from 7:30 to 9:30 AM on weekdays, to prevent garage access via the Kneeland-Hudson-Marginal-Washington route. Frequent police enforcement of this regulation would be essential to ensure compliance. Implementation of this measure would also require approval by the City of Boston's Transportation Department.

- Prohibition of turns onto Oak Street from Washington Street in the PM commuting period. With the Site 1

option, left turns from Washington Street onto Oak Street could be prohibited from 3:00 to 6:00 PM, which would prevent garage traffic from using the Washington-Oak-Harrison or Washington-Oak-Tyler routes for garage egress to I-93. Thus, garage-related traffic would be confined to Washington, Marginal, Herald, and Kneeland Streets. Similarly, right turns from Washington Street to Oak Street could be prohibited during the PM commuting period with Site 2. Again, City approval is a pre-condition for implementation of this measure.

- Another measure which could be viewed as either an alternative or supplement to turning restrictions would be the timing of signals to discourage local cut-through traffic. Current signal timing does, in fact, serve as an impediment to the use of Hudson Street as a cut-through to Washington, as reflected in the V/H travel time observations for the Hudson-Marginal-Washington route. These observations showed significant travel time delays at the Hudson Marginal and Marginal/Washington intersections, which resulted in the Hudson-Marginal-Washington cut-through being significantly slower than the Kneeland-Washington route. Travel time penalties on the cut-through can be measured through signal timing changes.

- To curtail the cut-through of traffic to the Posner Lot, via Harvard Street, NEMCH staff users could be reassigned to other facilities and Posner restricted to use by NEMCH visitors and patients only. NEMCH staff members are regular commuters and as such are more familiar with the roadway network and aware of shortcuts. Therefore, employees would have a greater tendency than visitors to use the Harvard Street cut-through.

- The section of Harvard Street between Harrison and Tyler could be closed to ensure the elimination of this roadway as a cut-through to NEMCH, specifically the Posner Lot.

- Reverse the one-way flow pattern on Tyler and Upper Hudson Streets to block cut-through traffic via Oak Street and Marginal Roads. Tyler would operate in the southbound direction and Upper Hudson in the northbound direction. This one-way pair would function as a loop and would not serve access or egress to/from Washington or Harrison Streets.

- Directional signing. This measure would involve the strategic posting of directional signing on area street corners to readily identify the designated routes to the garage. Accessing drivers would be directed by signs indicating a standard parking symbol and a directional arrow. Egressing drivers would be diverted from possible routes through the residential neighborhood by signs posted on the Washington/Oak Street intersection, in the case of Sites 1 and 2, prohibiting entry during the peak hours.

- Information Program. NEMCH currently issues a brochure of parking information which specifies the location, hours of operation, fees and regulations which apply at each of its parking facilities. This brochure could be expanded to provide directions to the parking facilities, directing vehicles via major roadways in the study area and bypassing local residential streets.

  Another related action would be to issue notices to employees and parking system users, urging that they travel to and from NEMCH parking areas via major study

are arterials, avoiding intrusion onto local community streets. These notices could be posted at various locations throughout the medical center and distributed periodically along with monthly parking passes, paychecks and at parking facility entrances or exits.

3. Increase the Availability of Spaces to Community Residents

While NEMCH parking facilities are filled to capacity on weekdays from 10:00 AM through 3:00 PM, there are capacity surpluses in most facilities at night, in the early morning and on weekends. The construction of an 850-space garage will serve to increase the availability of spaces, particularly during night and weekend hours.

NEMCH could institute a program under which a predetermined number of spaces at the new garage are made available to local community residents for parking overnight (between the hours of 5:00 PM and 8:00 AM) and on weekends. To ensure that the use of the garage by local residents does not interfere unduly with regular weekday garage operations, a limit of 100 to 200 spaces should be provided under this program, in conjunction with a new 850-space garage. Parking fees could be based upon direct operating costs (for security, monitoring) associated with community use of the facility and could be substantially lower than commercial rates.

Adequate and sensitive enforcement of restrictions governing community use of the facility is essential to the program's success. Subscribers' vehicles would require sticker identification. Violators of time restrictions would be towed after receiving several ticket warnings. Frequent towing could generate conflict between NEMCH and community parkers, which would defeat the purpose of this program. Repeat violators of time

restrictions should be expelled from the program. A simple and straightforward appeals process should be instituted, which would be administered by a committee consisting of several representatives of both NEMCH and the community.

4. Intersection Improvements

Operational improvements at key intersections on Kneeland and Herald Streets merit detailed study. These improvements would be designed to improve traffic flow via the major study area arterials, which would encourage garage-related traffic to travel on these roadways, rather than on cut-through routes. Specific measures which can be implemented are signal timing adjustments and restriction or removal of parking to allow lane use modifications. It is estimated that several traffic engineering improvements, as described below, could reduce projected delays at the Washington/Kneeland intersection by 25 to 33 percent.

- Signal timing should be examined and adjusted as appropriate at the intersections anticipated to experience impacts associated with garage operations. Most critical in this regard would be the Kneeland/Washington intersection under Sites 1 and 2, Herald/Harrison under Sites 2 and 3, and Herald/Washington under Site 3. The Kneeland/Washington intersection is estimated to operate in the AM at LOS "C" under the Site 1 option. Garage-bound traffic would turn left at the intersection onto Washington Street. Current signal timing at the intersection provides for a three-second left turn lead time, which will facilitate left-turn movements of garage-related traffic. To further improve intersection operations and reduce delays for left-turning traffic onto Washington Street, signal timing adjustments would be

beneficial, which would increase left-turn lead times to as much as ten seconds.

- Another beneficial action, under both Sites 1 and 2 would be the elimination of on-street parking at the Washington/Kneeland intersection, which would increase intersection capacity and improve traffic flow.

- On the Washington Street northbound approach, parking would be removed in the area 100 to 150 feet immediately south of the intersection, between the peak commuter hours of 7:00-9:00 AM and 3:00-6:00 PM. On the Kneeland westbound approach, parking is currently prohibited from 7:00-9:30 AM. This regulation should be strictly enforced and could be applied in the PM peak also.

- Relocation of the MBTA bus stop located approximately 100 feet to the south of the Washington/Kneeland intersection on Washington Street would also result in improved intersection traffic flow.

AIR QUALITY IMPACTS

SECTION IV
AIR QUALITY

A. INTRODUCTION

The objective of the Air Quality Analysis is to determine if the proposed new parking facility for the New England Medical Center Hospitals (NEMCH) will interfere with the attainment or maintenance of Massachusetts and National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO). The NAAQS were established by the Federal Clean Air Act, and are designed to protect both public health and welfare. To demonstrate compliance, it is necessary to identify those areas of human activity (sensitive receptors) exposed to maximum air pollutant levels from motor vehicle emissions in the project area. Using air quality modeling techniques, CO levels are estimated at these sensitive receptors for all project alternatives in the present and future years. Comparison of projected pollutant levels to the NAAQS permits evaluation of whether motor vehicle emissions related to the proposed parking facility will pose a threat to public health or welfare.

1. Pollutant Sources and Effects

The key source of project-related air pollution is emissions from motor vehicles in the area of the project site. Of the various air pollutants emitted, carbon monoxide (CO) is used in this analysis as an indicator of roadway air pollution levels, since it is the most abundant and persistent pollutant emitted by motor vehicles. Also, since CO is a non-reactive substance, its concentration in the air can be easily predicted.

The adverse health effects of carbon monoxide are a result of its combination with blood hemoglobin to form carboxyhemoglobin

(COHb). This compound interferes with the life-sustaining transfer of oxygen from the lungs to the body tissues and the return of carbon dioxide from the tissues to the lungs. The presence of relatively small amounts of CO results in significant interference with essential cardiovascular-respiratory functions. Brief exposure to high levels of CO can impair vision, physical coordination, and the perception of time.

National Ambient Air Quality Standards (NAAQS) for carbon monoxide have been set by the U.S. Environmental Protection Agency (EPA). Standards for the Commonwealth of Massachusetts are identical to the Federal standards. The standards, intended to protect the public health, set a maximum concentration of 35 parts per million (ppm) for a 1-hour period and 9 ppm for an 8-hour period, each not to be exceeded more than once per year. The target date for attainment of national CO standards in Massachusetts is December 31, 1987.

B. BACKGROUND AIR QUALITY

In urban areas such as Boston, there is always present in the air a fairly constant and diffuse level of CO due to the numerous sources spread throughout the metropolitan region and beyond. Such sources include all stationary fuel combustion facilities, as well as motor vehicle emissions on roadways. This diffuse level of air pollution is called the background level.

Background air quality can be determined by monitoring and testing air samples. Although no state monitoring station exists at the parking garage sites, the Massachusetts Department of Environmental Quality Engineering (DEQE) does collect CO samples at a site on Essex Street approximately four blocks north. Based on the Essex Street data, background levels of CO for 1984 in the study area were estimated by the DEQE[1] to be 7.0 ppm (1-hour

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1/ Personal communication, Mr. Jerome Grafe, Massachusetts Division of Air Quality Control, DEQE, Boston, MA, March 28, 1986.

average) and 5.0 ppm (8-hour average). It is necessary to estimate a value for the background CO level in this study since it is added to the impact of local sources (namely, roadway intersections in the study area) in determining whether air quality at a particular location complies with the NAAQS. Background levels of CO for 1990 were estimated to be 3.9 ppm (1-hour) and 2.8 ppm (8-hour), as discussed in Appendix C.

C. METHODOLOGY FOR ESTIMATING AIR QUALITY

The technical approach used to predict ambient air quality was approved in advance by the Massachusetts DEQE.[2] The analysis calculated maximum 1-hour and 8-hour CO concentrations at sensitive receptors near four intersections in the project area for the following four cases:

Case No.	Year	Development Alternative
1	1990	No-Build
2	1990	Build Garage Option 1
3	1990	Build Garage Option 2
4	1990	Build Garage Option 3

The intersections studied were:

1) Washington Street/Kneeland Street
2) Washington Street/Oak Street
3) Washington Street/Herald Street
4) Harrison Street/Oak Street

These intersections were selected based on a review of land use, existing traffic congestion, and expected travel routes for the proposed garage sites, and in consultation with the DEQE and BRA staffs. Since CO levels are highest near intersections where traffic congestion occurs, compliance with the NAAQS at these locations protects public health elsewhere in the community. The receptor locations are shown in Figures 1 through 4.

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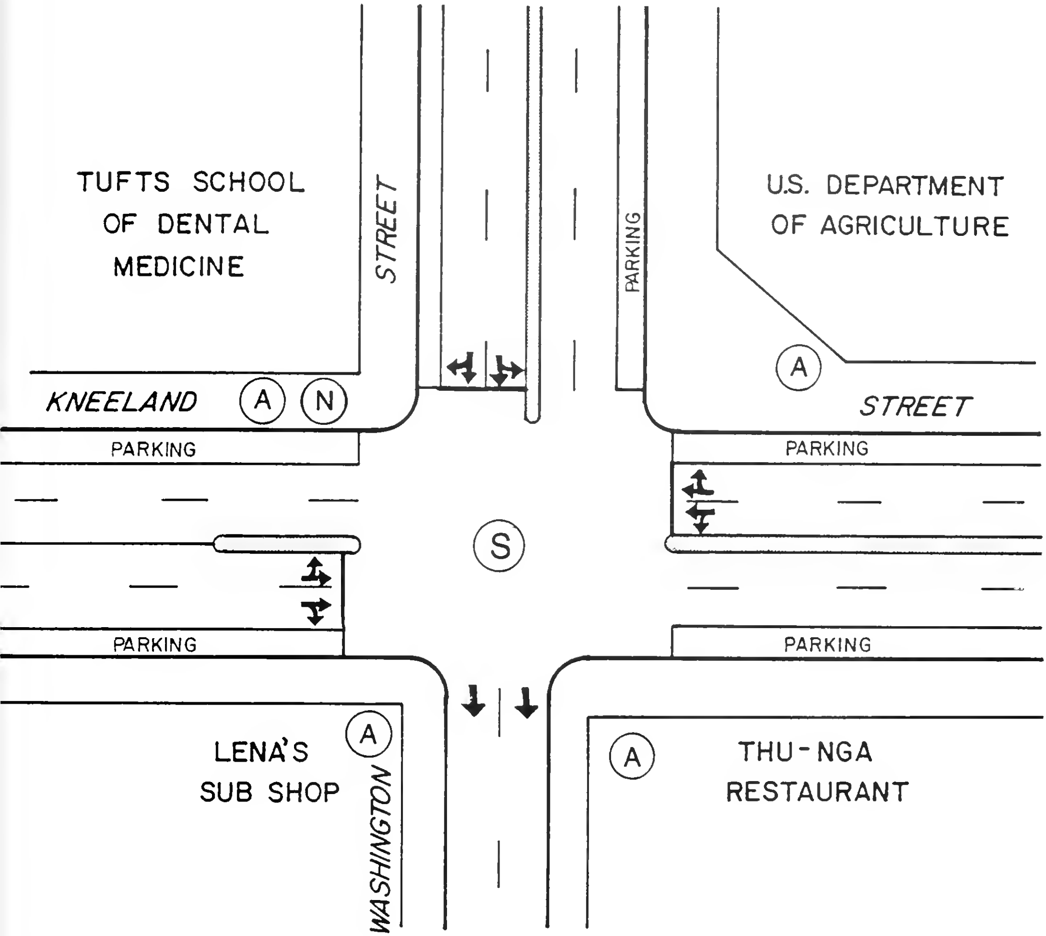
2/ Ibid.

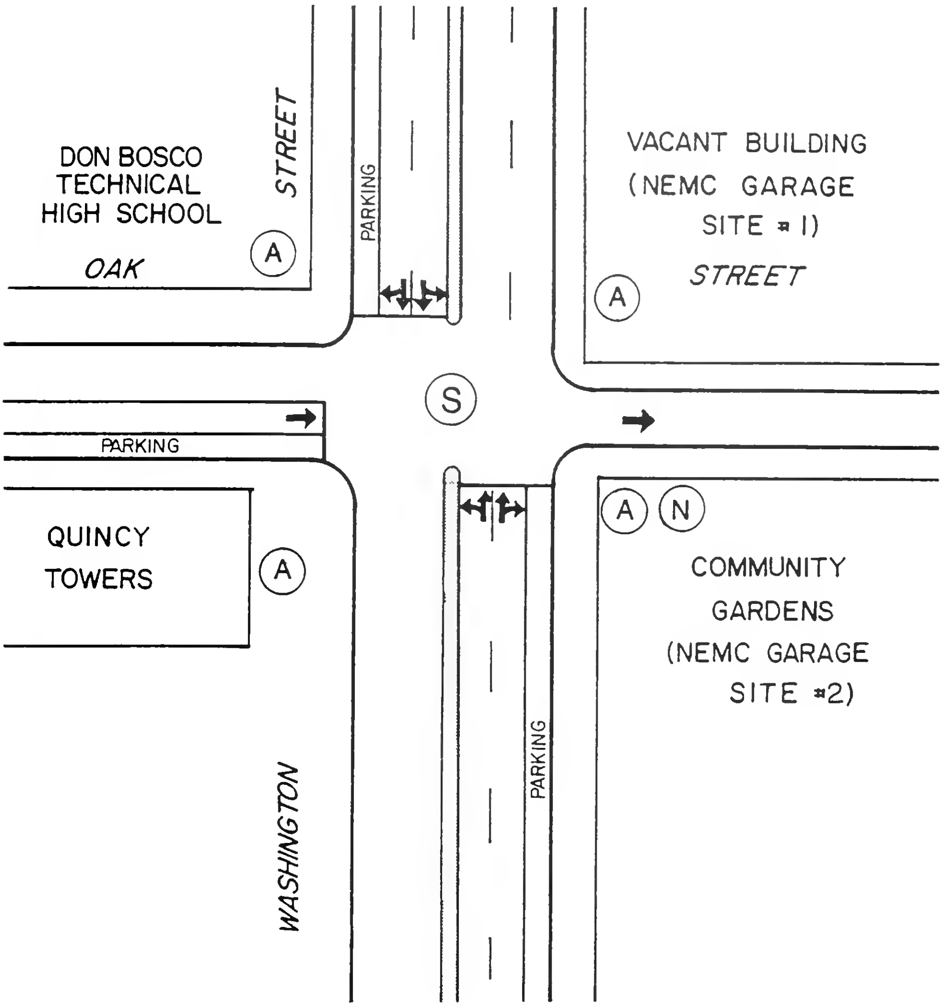


Air Quality (A) and Noise (N) Receptors Washington Street/ Kneeland Street

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Scale 1" = 50'

Fig. 1

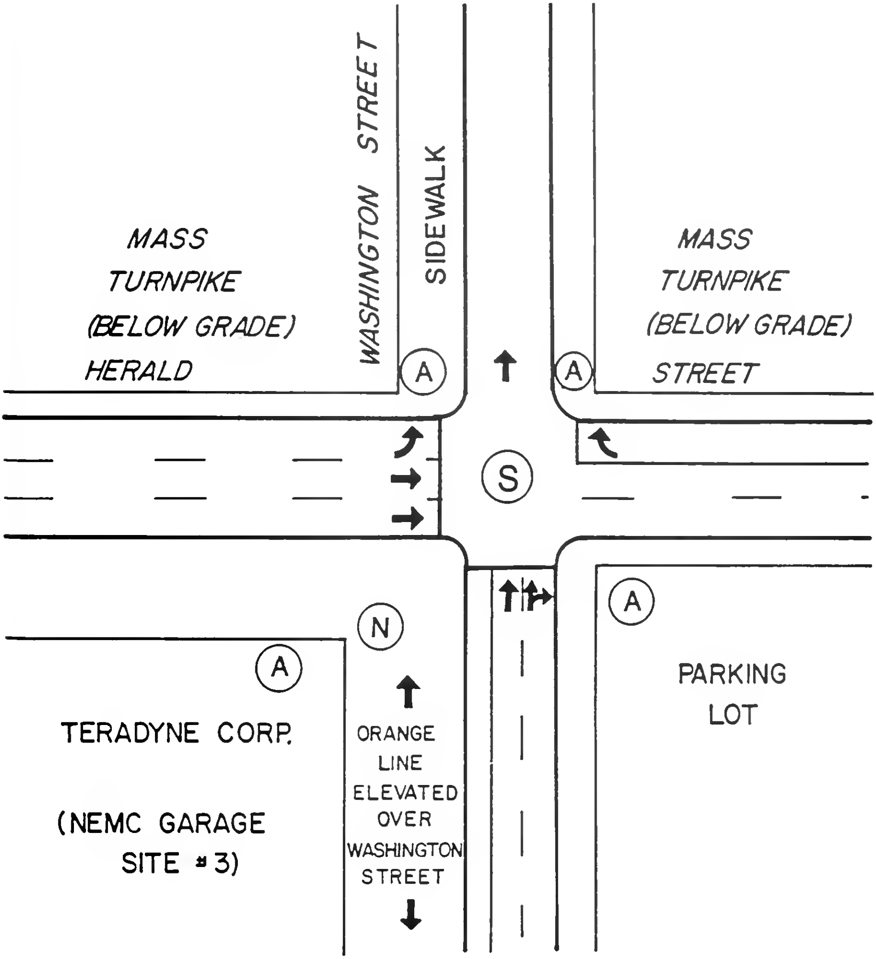


Air Quality (A) and Noise (N) Receptors Washington Street/ Oak Street

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Scale 1" = 50'

Fig. 2

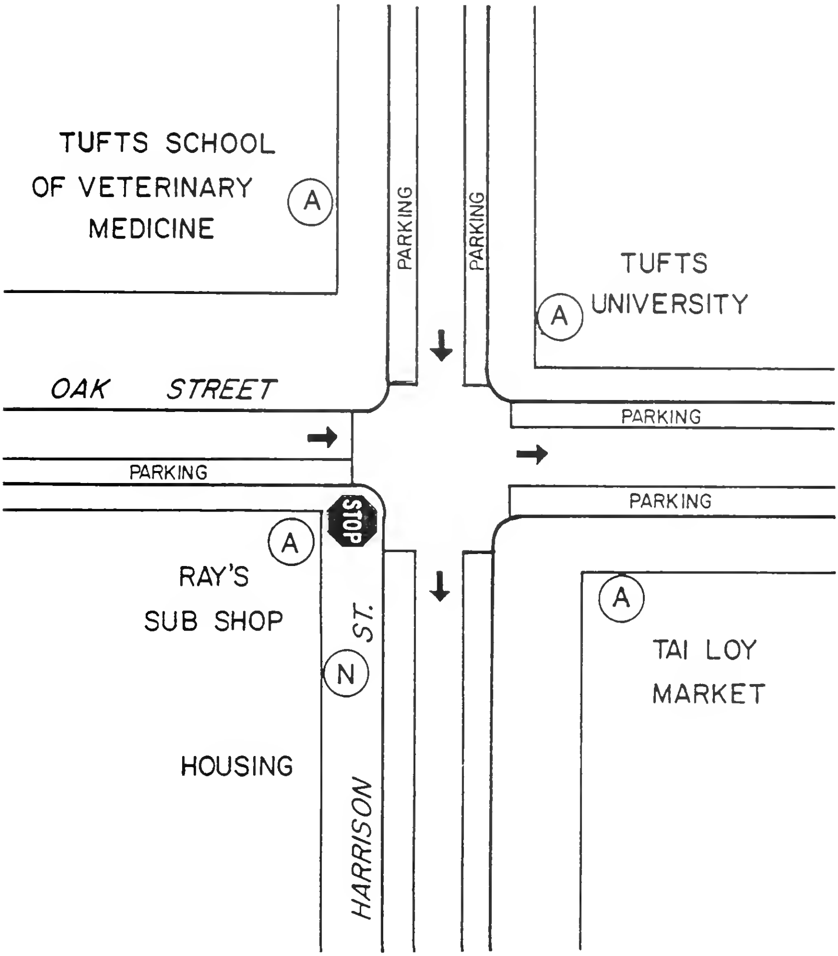


Air Quality (A) and Noise (N) Receptors Washington Street/ Herald Street

Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Scale 1" = 50'

Fig. 3



Air Quality (A) and Noise (N) Receptors Harrison Street/ Oak Street

Vanasse Hangen
Consulting Engineers & Planners
60 Birmingham Parkway Boston, MA 02135

Scale 1" = 50'

Fig. 4

Two mathematical models were used to predict air quality concentrations from roadway intersection traffic. The first, MOBILE-3,[3] was used to calculate the emissions of CO at an intersection based on traffic flow. The second model, CALINE-3,[4] was used to predict concentrations of CO at sensitive human receptors near the intersection. In addition, the impacts from the three alternative parking garage sites under study were calculated at adjacent intersections. A detailed description of the technical approach is given in Appendix C.

D. PROJECT IMPACTS

The air quality analysis predicted maximum 1-hour and 8-hour CO concentrations at 16 sensitive receptors. Details of the analysis are included in Appendix C. The cumulative results of the air quality analysis including impacts from intersection traffic, parking garage traffic, and background carbon monoxide are presented in Tables 1 and 2. These results do not characterize typical air pollution levels in the project area. Rather, they represent the highest concentrations that could exist during the joint occurrence of worst case meteorology and peak traffic.

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3/ EPA, User's Guide to MOBILE-3 (Mobile Source Emissions Model), EPA-460/3-84-002, Ann Arbor MI, June 1984, including software corrections from EPA date May, 1985.

4/ California Department of Transportation, CALINE-3, A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets, FHWA/CA/TL-79/23, Sacramento, CA, November, 1979.

TABLE 1
PREDICTED MAXIMUM 1-HOUR CO CONCENTRATIONS site
AT SENSITIVE RECEPTORS (PPM)*

Receptor Location	1990 No-Build	1990 Build Option 1	1990 Build Option 2	1990 Build Option 3
Washington St./Kneeland St.				
Tufts Dental School	9.9	10.2	10.0	9.9
U.S. Dept. of Agriculture	10.4	10.5	10.4	10.4
Thu-Nga Restaurant	9.2	9.4	9.3	9.2
Lena's Sub Shop	11.0	11.5	11.1	11.0
Washington St./Oak St.				
New England Medical Center	6.2	9.2	7.9	6.2
Northeast Corner	6.6	9.1	8.4	6.6
Southeast Corner	6.9	9.4	8.5	6.9
Quincy Towers	6.2	8.6	7.9	6.2
Washington St./Herald St.				
Northwest Corner	12.7	12.7	12.7	14.9
Northeast Corner	13.0	13.0	13.0	15.0
Parking Lot	15.4	15.5	15.5	17.4
Teradyne Corp.	12.7	12.7	12.7	14.5
Harrison St./Oak St.				
Tufts Veterinary School	5.8	5.9	5.9	5.8
Tufts University	6.7	6.7	6.9	6.7
Tai Loy Market	6.2	6.2	6.3	6.2
Ray's Sub Shop	7.4	7.5	7.5	7.4

* The 1-Hour CO air quality standard is 35 ppm.

1st routing alternative

? qualitative statement.

Quantify → Q'li

1468/886/wpr

TABLE 2
PREDICTED MAXIMUM 8-HOUR CO CONCENTRATIONS
AT SENSITIVE RECEPTORS (PPM)*

Receptor Location	1990 No-Build	1990 Build Option 1	Option 2	Option 3
Washington St./Kneeland St.				
Tufts Dental School	4.8	4.8	4.8	4.8
U.S. Dept. of Agriculture	5.2	5.3	5.3	5.2
Thu-Nga Restaurant	4.8	4.8	4.8	4.8
Lena's Sub Shop	5.4	5.5	5.5	5.4
Washington St./Oak St.				
New England Medical Center	3.6	3.6	3.6	3.6
Northeast Corner	3.6	3.6	3.7	3.6
Southeast Corner	3.8	3.9	4.0	3.0
Quincy Towers	3.4	3.5	3.7	3.4
Washington St./Herald St.				
Northwest Corner	6.1	6.1	6.1	6.2
Northeast Corner	5.6	5.6	5.6	5.7
Parking Lot	6.7	6.7	6.7	6.8
Teradyne Corp.	6.0	6.0	6.0	6.2
Harrison St./Oak St.				
Tufts Veterinary School	3.6	3.6	3.6	3.6
Tufts University	3.8	3.8	3.9	3.9
Tai Loy Market	3.6	3.6	3.6	3.6
Ray's Sub Shop	4.2	4.3	4.3	4.2

* The 8-Hour CO air quality standard is 9 ppm.

The modeling results for the 1990 No-Build case show all 1-hour and 8-hour CO concentrations are in compliance with the NAAQS. Maximum 1-hour values range from 5.8 to 15.4 ppm, compared to the 1-hour standard of 35 ppm, while 8-hour levels range from 3.4 to 6.7 ppm, compared to the 8-hour standard of 9 ppm. Air pollution levels for the No-Build case are highest at the intersection of Washington Street with Herald Street, and lowest at the intersection of Washington Street with Oak Street.

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The 1990 Build air quality projections show that the proposed garage will increase CO concentrations due to additional roadway traffic and garage emissions. Maximum 1-hour and 8-hour CO levels nevertheless will remain in compliance with the NAAQS for Sites 1, 2 and 3. Measured in terms of 1-hour maximum CO concentrations, Site 1 impacts will be greatest at the Washington/Oak Street intersection, where these concentrations would increase by 2.4 ppm to 3 ppm above existing levels. At the Washington/Kneeland Street intersection, maximum 1-hour concentrations will increase by 0.1 to 0.2 ppm. Increases at the other two intersections studied will be minimal. In the case of Site 2, 1-hour maximum concentrations will increase by less than 2 ppm at the Washington/Oak intersection and by no more than 0.1 ppm at the Washington/Kneeland intersection. Compared to Site 1, however, 1-hour maximum CO concentrations at the Harrison/Oak intersection will be greater in the case of Site 2, increasing by 0.2 ppm at one corner receptor and 0.1 ppm at two others. Site 3 would affect 1-hour maximum concentrations only at the Washington/Herald intersection where the concentrations will increase by 1.8 to 2.2 ppm above existing conditions. At all locations, 1-hour maximum concentrations will be well within the NAAQS standards under all site options.

The more binding standard is the 8-hour CO concentration of 9.0 ppm. In the case of Site 1, there is a 0.1 ppm increase in 8-hour concentrations at receptors on two corners of the Washington Street/oak Street intersection, and a 0.1 ppm increase in 8-hour CO concentrations at one corner of the Washington Street/Kneeland Street intersection. In the case of Site 2, there is again a 0.1 ppm increase in CO concentrations at one corner of the Washington Street/Kneeland Street intersection. CO concentrations are somewhat greater at the Washington Street/Oak Street intersection under the Site 2 option than in the case of Site 1, increasing by 0.2 ppm at two corners and 0.1 ppm at a

third corner. A 0.1 ppm increase in CO concentrations also occurs at one corner of the Harrison Street/Oak Street intersection. The impacts are insignificant at the other two intersections for Options 1 and 2.

Option 3 increases peak hour CO concentrations he most at the location where they are already high, namely Washington and Herald Streets, where concentrations will rise by 0.1 ppm at three corners and 0.2 ppm at the fourth corner. Of the three options, the highest CO levels occur for Option 3.

Based on these results, Site 1 is preferable to Sites 2 and 3 in terms of air pollution impacts. For all three sites, measures to mitigate air quality impacts would parallel those for traffic impacts, namely those that reduce peak hour volumes, delay times, and increase roadway capacity either through geometry and signalization improvements or demand reduction strategies.

With regard to 1-hour maximum concentrations, none of the sites would result in serious adverse impacts. At the intersection that is most sensitive from the local community's standpoint -- Harrison and Oak -- Site 2 impacts would be slightly worse than the impacts associated with Site 1. In terms of 8-hour concentrations which come closer to the NAAQS standards and may be more meaningful, Site 1-related impacts at the Harrison/Oak intersection and other receptors are same or lower than in the case of Site 2. Site 3 impacts are worse than Site 1 impacts at two of the four intersections including Harrison/Oak.

Site 1, 2. similar.
overall not much difference agst options.

1468/886/wpr

NOISE IMPACTS

SECTION V
NOISE

A. INTRODUCTION

The principal objective of the noise impact analysis was to quantify the effects of increased motor vehicle activity associated with the proposed NEMCH parking garage on sensitive receptors in the community. To accomplish this, ambient monitoring was performed to establish existing noise levels, and future noise levels were modeled at four representative receptors. The estimated increase in future noise levels can be compared to audible change criteria, while the total traffic noise level can be compared to U.S. Environmental Protection Agency (EPA) noise guidelines.

1. Common Measures of Community Noise

The unit of sound pressure is the decibel (dB). The decibel scale is logarithmic to accommodate the wide range of sound intensities to which the human ear is subjected. Another property of the decibel scale is that the sound pressure levels of two separate sounds are not directly additive. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (or 73 dB), not a doubling to 140 dB. Thus, every 3 dB increase represents a doubling of sound intensity.

Non-steady noise exposure in a community is commonly expressed in terms of the A-weighted sound level (dBA); A-weighting approximates the frequency response of the human ear. Since levels of many sounds change from moment to moment, this variation must be accounted for when measuring environmental

noise. One method of doing so is to determine the value of a single steady-state sound that has the same A-weighted sound energy as the time-varying sound. This is termed the Equivalent Sound Level (Leq). The virtue of Leq is that it correlates reasonably well with the effect of noise on people, even for wide variations in sound levels and time patterns.

Leq averaged over a 24-hour period is the noise value used by EPA in their guidelines[5] to protect public hearing. These guidelines state that an acceptable level of noise is 70 dBA (Leq 24) which will cause less than 5 dBA of hearing loss over 40 years exposure.

The City of Boston has regulations for the control of noise. they do not, however, apply to "the operation of any motor vehicle public way, nor to the noise produced thereby."[6] Since the NEMCH parking garage will only generate noise through the operation of motor vehicles, the City's regulations do not apply.

2. Characteristics of Community Noise

The noise environment of an urban community results from numerous sources. Major contributors are vehicular traffic, aircraft overflight, and industrial operations. Typical sound levels associated with various activities and environments are presented in Table 3.

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5/ U.S. Environmental Protection Agency, Protective Noise Levels - Condensed Version of EPA Levels Document, EPA 550/9-79-100, Washington, D.C., November 1978.

6/ Air Pollution Control Commission, City of Boston, "Regulations for the Control of Noise in the City of Boston," Section 2.1(c).

TABLE 3
COMMON NOISE LEVELS

Activity	dBA
Threshold of pain	130
Chipping on metal	120
Loud rock band	110
Jack hammer	100
Jet airliner 1/2 mile away	95
Threshold of hearing damage	90
Freeway traffic	80
Urban traffic	70
Electric typewriters	65
Normal conversation	60
Urban residential area	50
Quiet suburban area	45
Soft whisper at 5 feet	35
Wilderness area	25
Threshold of audibility	0

In the project area, ambient noise levels are dominated by vehicular traffic and the MBTA elevated orange line and are highest along Washington Street, particularly near the Massachusetts Turnpike, and are significantly lower along Harrison Street.

B. EXISTING NOISE LEVELS

Four receptor locations were selected in consultation with the Massachusetts Department of Environmental Quality Engineering at the four intersections studied for air quality impacts. Receptors were chosen to represent the greatest exposure to

maximum levels and are shown in Figures 1 through 4 of Section 3. All are sidewalk locations and are described as follows:

- Receptor - Site 1 (Commercial/Institutional) - On the southeast corner of Washington and Kneeland Streets in front of the Tufts School of Dental Medicine.

- Receptor - Site 2 (Institutional/Residential) - On the southeast corner of Washington and Oak Streets in an area currently used for community gardens and the future site of the Site 2 NEMCH garage option

- Receptor - Site 3 (Industrial) - On the southwest corner of Washington and Herald Streets in front of Teradyne Corporation.

- Receptor - Site 4 (Residential/Commercial Institutional) - On Harrison Street just south of the intersection with Oak Street in front of housing units.

Existing noise levels at these receptors were both measured and modeled. An ambient noise monitoring program was performed on June 14, 1986 using a Quest Micro-15 Integrating Noise Analyzer. Values of 1-hour Leq were estimated from 10-minute measurements and simultaneous traffic counts were recorded on nearby roadways. Noise measurements listed in Table 4 were taken during the afternoon period of peak traffic.

At all four locations noise sources other than motor vehicle traffic are also significant. At Receptor - Site 1, pedestrian traffic is substantial. At Receptor - Sites 2 and 3, MBTA orange line trains passing about every three minutes drowned out the traffic noise. Train noise was greatest at Receptor - Site 3

TABLE 4
AMBIENT NOISE MEASUREMENTS (dBA)

Time	Receptor Site		Leq
1702-1712	Washington/Kneeland	1	73.8
1601-1611	Washington/Oak	2	73.5
1630-1640	Washington/Herald	3	81.2
1550-1600	Harrison/Oak	4	64.1

where the tracks are directly overhead on Washington Street and peak noise levels of 102 dBA were measured. At Receptor - Site 4, additional sources are air conditioners running in nearby buildings and some orange line noise in the distance.

The traffic counts taken during the noise measurements were input to the FHWA Highway Traffic Noise Prediction Model[7] to validate the model for the project site. This model only accounts for motor vehicle noise sources. The worksheet is included at the end of this section, and the results are summarized in Table 5.

TABLE 5
COMPARISON OF MEASURED AND MODELED NOISE LEVELS
(1-Hour Leq in dBA)

Site No.	Measured	Modeled
1	73.8	75.6
2	73.5	68.1
3	81.2	72.0
4	64.1	63.6

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7/ Federal Highway Administration, FHWA Highway Traffic Noise Prediction Model, FHWA-RD-77-108, Washington, D.C., December 1978.

The model does a good job at Sites 1 and 4, slightly over-predicting (+1.8 dBA) noise at Site 1 and underpredicting (-0.5 dba) at Site 4. At Sites 2 and 3, however, the model significantly underpredicts total noise because it does not represent the elevated orange line as a noise source. Assuming an unbiased model for roadway noise, equivalent Leq levels for the orange line trains at Sites 2 and 3 are 72.0 and 80.6 dBA, respectively. Since the Orange Line will be relocated underground by 1990, future noise levels at Receptor Sites 2 and 3 will be significantly lower.

C. PROJECT IMPACTS

At the four receptor sites, 24-hour Leq noise levels were modeled for the 1990 No-Build and 1990 garage site 1, 2, and 3 alternatives -- details are found in Appendix D, and the model output is summarized in Table 6.

TABLE 6
PREDICTED FUTURE NOISE LEVELS AT
FOUR RECEPTOR LOCATIONS
(24-Hour Leq in dBA)

	Receptor Site 1	Receptor Site 2	Receptor Site 3	Receptor Site 4
1990 No-Build	74.3	68.4	71.5	65.9
Build Site 1	74.3	69.0	71.5	66.1
Build Site 2	74.2	69.7	71.5	66.2
Build Site 3	74.4	68.5	71.7	66.0

For the 1990 No-Build case, 24-hour Leq noise ranges from a low of 65.9 dBA at Site 4 up to a high of 74.3 dBA at Site 1. These levels are typical for an urban area. Levels are above the EPA noise guideline at Sites 1 and 3 due to high traffic volumes. Noise levels are below the EPA guideline in the residential areas

at Sites 2 and 4. Noise levels inside nearby buildings will be at least 15 to 25 dBA less.

Build Site 1 increases Leq values from 0.2 to 0.6 dBA at three of the noise receptor sites. Since noise changes of 1 dBA or less are generally not perceptible, the increases in noise associated with Option 1 will be imperceptible to area residents in the community. Build Option 2 increases Leq values by 0.0 to 1.3 dBA at three of the sites, with the greatest increase occurring at Site 2, a mixed residential/institutional receptor. Noise increases associated with garage site 2 are above 1 dBA and hence will be perceived by the community. Increases for Option 3 are at most only 0.2 dBA. Again, these increases will be imperceptible to area residents.

In summary, the noise impact of the traffic associated with NEMCH garage sites 1 and 3 is predicted to be imperceptible. The greatest increase in 24-hour Leq noise (to 1.3 dBA) will occur for garage site 2 at the intersection of Washington and Oak Streets. The noise impact associated with garage operations at Site 2 will be perceptible.

TECHNICAL APPENDIX A
TRAFFIC COUNT SCHEDULE AND DATA

APPENDIX B

SURVEY FORM AND RESPONSES

2315

N.E.M.C.H.
TRANSPORTATION AND PARKING SURVEY

This survey is being conducted to determine the need for additional parking facilities and improved transportation services at the New England Medical Center. Your cooperation is needed for the success of this survey. We therefore urge you to complete all applicable items listed below. All survey responses will be completely confidential and will be used only for the purpose of transportation and parking analysis.

PLEASE complete the questionnaire when you get it and return it TODAY to survey personnel or one of the COLLECTION BOXES located at selected hospital entrances.

1. What is your reason for coming to the hospital today? (check one)

Hospital Personnel: I am a:

___ Physician
___ Nurse
___ Ancillary Staff
___ Non-Medical Staff
___ Other ________ (please specify)

Non-Employee: I am a:

___ Inpatient
___ Outpatient
___ Visiting a Patient
___ Business Visitor
___ Cafeteria Visitor
___ Volunteer
___ Student
___ Accompanying a Patient
___ Making a Delivery
___ Other ________ (please specify)

5 6

2a. How did you arrive at the hospital today? (check one)

___ Drove Car and Parked
___ Passenger in Car that Parked (Non-Driver)
___ Dropped-Off by Car
___ Subway
___ Bus
___ Taxi
___ Walked Only (no use of vehicle)
___ Bicycle/motorcycle
___ Other ________ (please specify)

7

8

2b. Is this your usual mode of transportation? ___ yes ___ no
If not, specify usual mode ________.

9

3. (DRIVERS ONLY) When you arrived at the Hospital today, how many people were in the car, including yourself? (check one)

___one ___two ___three ___four ___five ___six ___more than six

10

4. (SUBWAY RIDERS ONLY) At which station did you get off the train?

___ Essex (Orange Line)
___ Park Street (Red/Green Line)
___ Boylston (Green Line)
___ Other ________ (please specify)

11

5. (BUS RIDERS ONLY) On which bus route did you ride to the hospital?

Bus Route No. ____

12 13

6. (SUBWAY AND BUS RIDERS ONLY) Why did you choose transit as your mode of transportation to the hospital? (check one)

___ No automobile available
___ Difficult to find parking space
___ Parking too expensive
___ Train/bus more convenient than automobile
___ Other ________ (please specify)

14

7. (SUBWAY AND BUS RIDERS ONLY) Do you purchase an MBTA monthly transit pass? ___ yes ___ no

15

Questions 8 through 10 should be answered by ALL survey respondents

8. From what city or town did you begin your trip to the hospital today?
________ Name of City or Town - specify neighborhood if Boston

16 18

9. At what time did you arrive at the Hospital? (specify time)
__:__ AM or __:__ PM

19 22

10. What is your destination at the hospital today?
(See map on reverse side and check location below).

___ A-Biewend
___ B-Boston Dispensary
___ C-Center
___ D-37 Bennett
___ E-Farnsworth
___ F-Floating Hospital
___ G-Holmes
___ H-Pratt
___ I-Proger
___ J-Dental School/Clinic
___ K-Rehabilitation Inst.
___ L-Ziskind
___ M-Nassau St.
___ N-15/35 Kneeland St.
___ O-Tufts U. (Med., Vet. or Health School, Sackler)
___ P-Other ________ (please specify)

23 24

11. (DRIVERS ONLY) Where did you park? (See map on reverse side and check location below).

___ 1.Tremont St. Garage
___ 2.Shopper's Garage
___ 3.Posner Lot
___ 4.Oak St. Lot
___ 5.Washington St. Lot
___ 6.Herald Street Garage
___ 7.On-street(Chinatown) ________ (specify street)
___ 8.On-street (Other) ________ (specify street and/or neighborhood)
___ 9.Other Garage/Lot ________ (specify name and/or location)

25 26

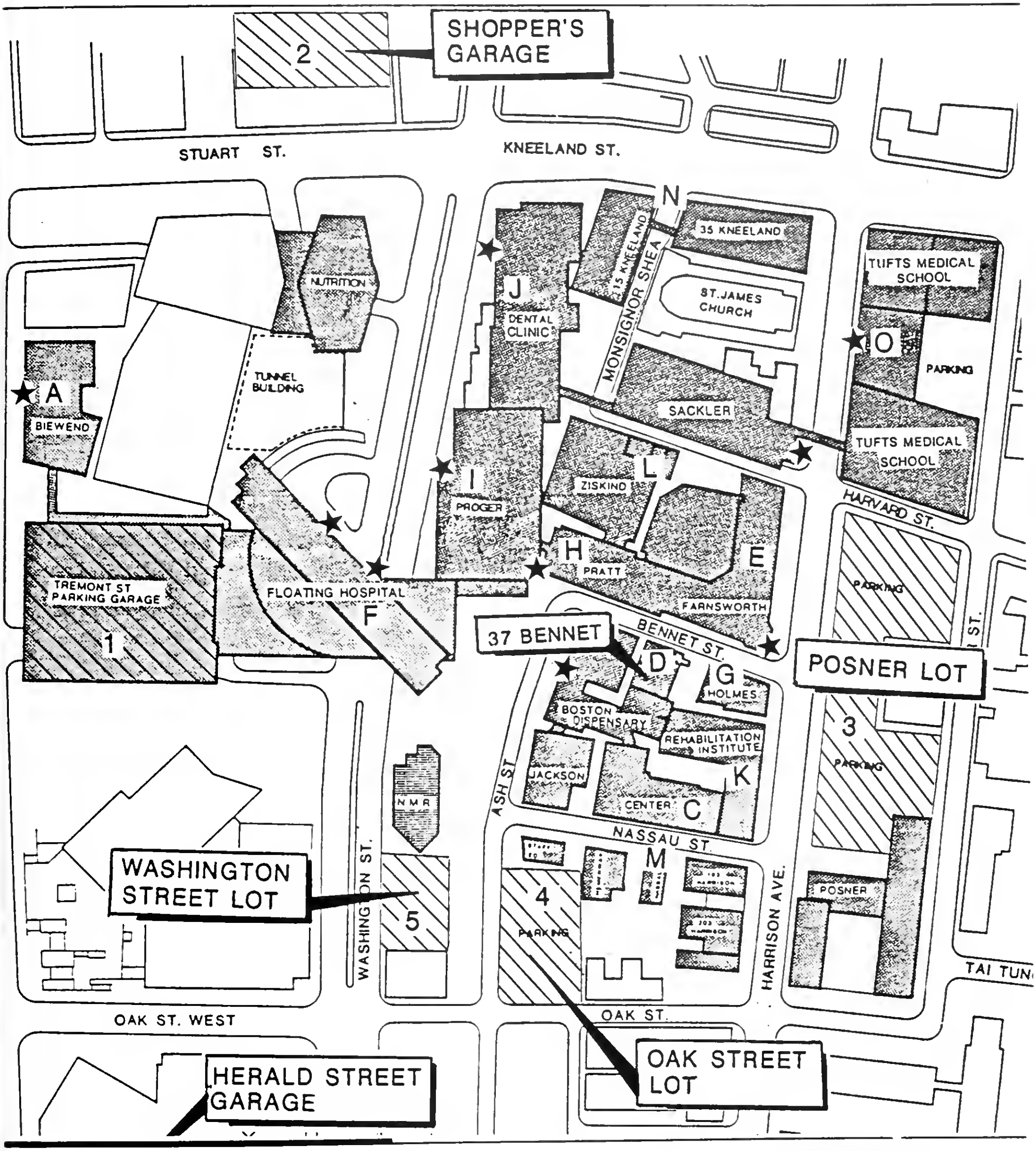
12. At what time will you leave the hospital today?
__:__ AM or __:__ PM

27 30

13. Comments ________

31

THANK YOU for completing this survey. Please return to survey personnel or in one of the collection boxes provided at selected hospital entrances.



Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Survey Distribution Locations

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	PERCENT
WHERE ARE YOU GOING?		
BICWEND	[illegible]	[illegible]
BOSTON DISPENSARY	[illegible]	[illegible]
CENTER	[illegible]	[illegible]
37 BENNET	[illegible]	[illegible]
FARNSWORTH	149	[illegible]
FLOATING HOSPITAL	791	[illegible]
HOLMES	15	.7%
PRATT	68	[illegible]
PROGER	237	11.7%
DENNTAL SCHOOL	[illegible]	[illegible]
REHABILITATION BUILDING	24	1.2%
ZISKIND	88	4.3%
NASSAU ST	15	.7%
15-35 KNEELAND ST	[illegible]	1.5%
TUFTS UNIVERSITY	276	[illegible]
NURSING OFFICE	[illegible]	[illegible]
O.R.	[illegible]	[illegible]
OTHER	[illegible]	[illegible]
POSNER	1	.0%
SPORTS THERAPY	1	.0%
SYSTEM PARKING	1	.0%
TREMONT ST GARAGE	2	.1%
TUPPER	2	.1%
MORE THAN 1 HOSPITAL LOCATION	66	3.3%
MORE THAN 1 TUFTS-HOSP LOCATION	19	.9%
34	1	.0%
TOTAL	2032	100.0%
WHERE DID YOU PARK?		
TREMONT ST GARAGE	505	[illegible]
SHOPPER"S GARAGE	[illegible]	[illegible]
POSNER LOT	132	12.8%
OAK ST LOT	40	3.9%
WASHINGTON ST LOT	46	4.5%
HERALD ST GARAGE	171	16.5%
56	1	[illegible]
UNSPECIFIED	14	[illegible]
ASH ST	3	[illegible]
BENNET ST	2	.2%
HARRISON ST	23	2.2%
KNEELAND ST	6	[illegible]
NASSAU ST	6	.6%
SHAWMUT AVE	1	[illegible]
TREMONT ST	[illegible]	[illegible]
TYLER ST	1	[illegible]
WASHINGTON ST	[illegible]	[illegible]
UNSPECIFIED	[illegible]	[illegible]
D ST	[illegible]	[illegible]
WARREN ST	[illegible]	[illegible]
39	1	[illegible]
UNSPECIFIED	[illegible]	[illegible]
AUTO PARKS-TREMONT	3	[illegible]
BACK BAY	1	.1%

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	PERCENT
BOSTON COMMON	1	[illegible]
DON BOSCO [illegible]	5	[illegible]
KERNEY LOT	1	[illegible]
TUFTS MEDICAL [illegible]	1	[illegible]
UNIVERSITY LOT	1	.1%
TOTAL	[illegible]	[illegible]
WHAT TIME WILL YOU DEPART?		
100	2	.1%
330	1	.1%
600	1	.1%
700	8	.4%
730	6	.3%
800	16	.9%
830	4	.2%
900	17	.9%
930	7	.4%
1000	31	1.6%
1030	23	1.2%
1100	54	2.8%
1130	28	1.5%
1200	45	2.4%
1230	20	1.1%
1300	38	2.0%
1330	21	1.1%
1400	41	2.2%
1430	36	1.9%
1500	84	4.4%
1530	92	4.8%
1600	194	10.2%
1630	154	8.1%
1700	368	19.4%
1730	90	4.7%
1800	197	[illegible]
1815	1	.1%
1830	58	3.1%
1900	77	4.1%
1930	18	.9%
2000	60	3.2%
2030	4	.2%
2100	27	1.4%
2130	2	.1%
2200	12	.6%
2230	1	.1%
2300	27	1.4%
2330	18	.9%
2400	[illegible]	[illegible]
7890	1	[illegible]
TOTAL	[illegible]	[illegible]
WHERE DID YOU BEGIN TRIP?		
ABINGTON	1	[illegible]
ACUSHNET	3	.1%

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	PERCENT
AMESBURY	1	[illegible]
ANDOVER	[illegible]	[illegible]
ARLINGTON	[illegible]	[illegible]
ASHLAND	[illegible]	[illegible]
ATTLEBORO	[illegible]	[illegible]
AVON	1	[illegible]
AYER	[illegible]	[illegible]
BARNSTABLE	1	[illegible]
BEDFORD	[illegible]	[illegible]
BELLINGHAM	[illegible]	[illegible]
BELMONT	[illegible]	[illegible]
BEVERLY	5	.2%
BOSTON	95	4.7%
BACK BAY	26	[illegible]
BEACON HILL	[illegible]	.4%
ALLSTON/BRIGHTON	[illegible]	[illegible]
CHARLESTOWN	[illegible]	[illegible]
CHINATOWN	7	[illegible]
DORCHESTER	[illegible]	[illegible]
EAST BOSTON	28	[illegible]
FENWAY	7	.3%
FOREST HILLS	1	[illegible]
HYDE PARK	14	.7%
KENMORE SQUARE	3	.1%
MATTAPAN	23	1.1%
MISSION HILL	3	.1%
NORTH END	2	.1%
READVILLE	1	.0%
ROSLINDALE	23	1.1%
ROXBURY	19	.9%
SAVIN HILL	2	.1%
SOUTH BOSTON	77	3.8%
SOUTH END	25	1.2%
WEST END	3	.1%
WEST ROXBURY	11	.5%
BRAINTREE	20	1.0%
BRIDGEWATER	6	.3%
BROCKTON	24	1.2%
BROOKLINE	100	[illegible]
BURLINGTON	2	.1%
CAMBRIDGE	64	[illegible]
CANTON	9	[illegible]
CENTERVILLE	1	.0%
CHELMSFORD	3	.1%
CHELSEA	6	.3%
CHICOPEE	1	.0%
COHASSET	2	.1%
CONCORD	[illegible]	[illegible]
DANVERS	[illegible]	[illegible]
DARTMOUTH	[illegible]	[illegible]
DEDHAM	[illegible]	[illegible]
DIGHTON	[illegible]	[illegible]
DOVER	[illegible]	[illegible]
DRACUT	[illegible]	[illegible]
DUNSTABLE	[illegible]	[illegible]
DUXBURY	4	[illegible]
EAST FREETOWN	1	.0%

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	PERCENT
EASTON	3	[illegible]
ESSEX	1	[illegible]
EVERETT	[illegible]	.3%
FAIRHAVEN	[illegible]	[illegible]
FALL RIVER	4	.2%
FALMOUTH	4	[illegible]
FITCHBURG	2	.1%
FOXBORO	3	[illegible]
FRAMINGHAM	20	[illegible]
FRANKLIN	1	[illegible]
GARDNER	3	[illegible]
GEORGETOWN	1	[illegible]
GLOUCESTER	4	.2%
GRAFTON	2	.1%
GROTON	1	.0%
HANOVER	3	[illegible]
HANSON	1	.0%
HARVARD	1	[illegible]
HAVERHILL	7	.3%
HINGHAM	7	.3%
HOLBROOK	3	.1%
HOLLISTON	4	[illegible]
HOPKINTON	1	.0%
HUDSON	1	.0%
HULL	3	.1%
HYANNIS	2	.1%
IPSWICH	2	.1%
KINGSTON	2	.1%
LAWRENCE	6	.3%
LEOMINSTER	1	.0%
LEXINGTON	12	.6%
LINCOLN	3	.1%
LITTLETON	[illegible]	.0%
LOWELL	12	[illegible]
LYNN	16	[illegible]
LYNNFIELD	5	.2%
MALDEN	40	2.0%
MANCHESTER	2	.1%
MANSFIELD	2	.1%
MARBLEHEAD	[illegible]	[illegible]
MARLBORO	4	.2%
MARSHFIELD	11	.5%
MARSTON MILLS	1	.0%
MASHPEE	1	.0%
MAYNARD	2	.1%
MEDFIELD	3	.1%
MEDFORD	35	1.7%
MEDWAY	[illegible]	[illegible]
MELROSE	[illegible]	[illegible]
METHUEN	[illegible]	[illegible]
MIDDLEBORO	[illegible]	[illegible]
MILLIS	[illegible]	[illegible]
MILTON	[illegible]	[illegible]
NAHANT	4	[illegible]
NATICK	15	.7%
NEEDHAM	13	[illegible]
NEW BEDFORD	2	.1%

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	PERCENT
NEWBURY	[illegible]	[illegible]
NEWBURYPORT	5	[illegible]
NEWTON	114	[illegible]
NORFOLK	[illegible]	[illegible]
NORTHBORO	3	[illegible]
NORTH ANDOVER	1	[illegible]
NORTH ATTLEBORO	2	[illegible]
NORTH EASTON	3	.1%
NORTH READING	3	.1%
NORTON	1	.0%
NORWELL	7	[illegible]
NORWOOD	10	.5%
PEABODY	8	.4%
PEMBROKE	5	[illegible]
PLYMOUTH	6	.3%
PRINCETON	1	[illegible]
QUINCY	77	[illegible]
RANDOLPH	9	[illegible]
RAYNAM	1	.0%
READING	12	.5%
REHOBETH	2	.1%
REVERE	18	[illegible]
ROCKLAND	6	.3%
ROCKPORT	2	.1%
SALEM	9	.4%
SANDWICH	1	.0%
SAUGUS	8	.4%
SCITUATE	9	.4%
SHARON	3	.1%
SOMERVILLE	55	2.7%
SOUTHBORO	1	.0%
STONEHAM	12	[illegible]
STOUGHTON	13	.5%
SUDBURY	4	.2%
SWAMPSCOTT	[illegible]	.7%
TAUNTON	3	.1%
TEWKSBURY	5	.2%
TOPSFIELD	1	.0%
TOWNSEND	3	.1%
TYNGSBORO	1	.0%
UPTON	1	.0%
WAKEFIELD	9	[illegible]
WALPOLE	9	.4%
WALTHAM	19	.9%
WAREHAM	2	.1%
WATERTOWN	30	.5%
WAYLAND	5	.2%
WELLESLEY	23	[illegible]
WESTFORD	[illegible]	[illegible]
WESTON	[illegible]	[illegible]
WESTWOOD	6	[illegible]
WEYMOUTH	[illegible]	[illegible]
WHITMAN	[illegible]	[illegible]
WILMINGTON	[illegible]	[illegible]
WINCHESTER	[illegible]	[illegible]
WINTHROP	[illegible]	.8%
WOBBURN	12	.6%

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	PERCENT
WOLLASTON	[illegible]	[illegible]
WORCESTER	[illegible]	[illegible]
JAMAICA PL	7	[illegible]
ACTON	1	[illegible]
AMHERST	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
CONCORD	[illegible]	[illegible]
DANVILLE	[illegible]	[illegible]
DERRY	1	[illegible]
DOVER	[illegible]	[illegible]
GOFFSTOWN	1	[illegible]
HAMTON	1	[illegible]
LONDONDERRY	2	[illegible]
MANCHESTER	[illegible]	[illegible]
NASHUA	[illegible]	[illegible]
PLAISTOW	[illegible]	[illegible]
PORTSMOUTH	[illegible]	[illegible]
RAYMOND	[illegible]	[illegible]
SALEM	2	[illegible]
KITTERY	1	[illegible]
ORONO	1	[illegible]
PORTLAND	[illegible]	[illegible]
YORK BEACH	[illegible]	[illegible]
EAST GREENWICH	[illegible]	[illegible]
PAWTUCKET	1	[illegible]
PORTSMOUTH	1	[illegible]
PROVIDENCE	3	.1%
NORWICH	1	[illegible]
WESTPORT	1	[illegible]
CALIFORNIA	2	[illegible]
678	1	[illegible]
TOTAL	[illegible]	[illegible]

IS THIS YOUR USUAL TRIP MODE?	
YES	[illegible]
NO	[illegible]
1	
2	
TOTAL	[illegible]
IF NO, INDICATE NORMAL MODE	
COMMUTER RAIL	47
DROVE	[illegible]
RODE	62
DROPPED OFF	41
SUBWAY	535
BUS	94
TAXI	12
WALKED	169
BIKE/MCYCLE	[illegible]
VANPOOL	3
WHICH T STATION DO YOU USE?	
ESSEX ST	227
PARK ST	45
BOYLSTON ST	167
ARLINGTON ST	2
BROADWAY	8
COPLEY	3
STATE ST	5
WASHINGTON ST	83
TOTAL	540
WHICH BUSROUTE DO YOU TAKE?	
TBUS 3	1
TBUS 11	36
TBUS 39	1
TBUS 43	1
TBUS 49	1
TBUS 55	2
TBUS 93	1
TBUS 300	3
TBUS 301	10
TBUS 304	[illegible]
TBUS 305	[illegible]
14	1
15	1
20	[illegible]
21	2
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
25	[illegible]
26	[illegible]
27	[illegible]
TOTAL	89

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	PERCENT
WHY DO YOU TAKE TRANSIT?		
DON'T [illegible]	[illegible]	[illegible]
NO CAR	[illegible]	[illegible]
NO PARKING	[illegible]	[illegible]
TOO EXPENSIVE	[illegible]	[illegible]
CONVENIENCE	[illegible]	[illegible]
1 AND 4	[illegible]	[illegible]
2 AND 3	[illegible]	[illegible]
2 AND 4	[illegible]	[illegible]
3 AND 4	18	2.7%
MORE THAN 2	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]
DO YOU HAVE A T PASS?		
0	[illegible]	[illegible]
YES	[illegible]	[illegible]
NO	[illegible]	[illegible]
5	1	[illegible]
TOTAL	[illegible]	[illegible]
WHAT TIME DID YOU ARRIVE?		
300	1	[illegible]
500	2	[illegible]
530	[illegible]	[illegible]
600	37	1.9%
630	79	4.0%
700	184	9.3%
715	1	.1%
730	183	9.2%
800	329	16.5%
820	1	.1%
830	275	[illegible]
900	[illegible]	[illegible]
930	68	[illegible]
1000	67	[illegible]
1030	25	1.3%
1100	49	2.5%
1130	26	[illegible]
1200	21	[illegible]
1230	[illegible]	[illegible]
1300	[illegible]	[illegible]
1330	27	1.4%
1400	37	1.9%
1430	41	2.1%
1500	38	[illegible]
1530	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
1630	[illegible]	[illegible]
1700	[illegible]	[illegible]
1730	[illegible]	[illegible]
1800	[illegible]	[illegible]
1830	[illegible]	[illegible]
1900	15	[illegible]
1930	3	.2%

continued

NEW ENGLAND MEDICAL CENTER UNDADJUSTED SURVEY RESULTS

	FREQUENCY	[illegible]
[illegible]	[illegible]	
[illegible]		
[illegible]		
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]
[illegible]		
TOTAL	[illegible]	[illegible]

APPENDIX C

TECHNICAL APPROACH TO THE AIR QUALITY ANALYSIS

METHODOLOGY FOR THE INTERSECTION ANALYSIS

The microscale analysis predicted maximum 1-hour and 8-hour CO concentrations at receptors near four intersections in the study area for the following four cases:

Case No.	Year	Build Alternative
1	1990	No-Build
2	1990	Build Garage Option 1
3	1990	Build Garage Option 2
4	1990	Build Garage Option 3

The four intersections studied are:

1) Washington Street/Kneeland Street
2) Washington Street/Oak Street
3) Washington Street/Herald Street
4) Harrison Street/Oak Street

In all cases, the EPA MOBILE-3 computer program was used to calculate emissions and the CALINE-3 dispersion model was used to predict concentrations supplemented by a set of assumptions specified by the Department of Environmental Quality Engineering (DEQE).[1] These assumptions include an ambient air temperature of 33°F (December), and worst-case meteorological conditions of Pasquill-Gifford Class D stability in conjunction with a 1.0 meters per second (m/s) wind speed (1-hour) and a 1.6 m/s wind speed (8-hour), the worst-case wind direction (determined by analyzing all directions at 10 degree increments), a mixing height of 1,000 meters, a roughness length of 321 cm (for urban areas), and a vehicle spacing of 6 meters.

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1/ Personal communication, Mr. Jerome Grafe, Division of Air Quality control, Massachusetts DEQE, Boston MA, April 24, 1986.

The CO background levels for 1984 in the project area were assumed to be 7.0 ppm (1-hour) and 5.0 ppm (8-hour). The 1990 background levels were scaled from 1984 values by the fractional decrease in emission rates and the fractional increase in traffic. The CO emission rates used in this analysis decrease at least 46.8 percent from 1984 to 1990 (see section on calculation of emission rates at the end of this Appendix). In the same time period, peak hour base traffic in the Washington Street corridor is assumed to grow 1 percent per year. Thus, the calculated 1990 CO background levels are 3.9 ppm (1-hour) and 2.8 ppm (8-hour).

The EPA Region I Mobile Source Modeling Procedures[2] describe the proper use of the CALINE-3 dispersion model in a microscale analysis of free-flow and queuing emissions from motor vehicles at an intersection. EPA has programmed these procedures with the CALINE-3 model in a software package called CALQ3. CALQ3 was used in this analysis. A number of other state of the art techniques were used to enhance CALQ3 for special situations. In the case of signalized, over-capacity intersections, NCHRP Report 133[3] was employed to estimate queue lengths. For the stop sign controlled intersection of Harrison and Oak Streets capacity calculations are based on critical a 5-second gap time, and the queueing equations (6) and (7) in the EPA Indirect Source Guideline Model[4] were used

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2/ EPA Region I, Region I Mobile Source Modeling Procedures, Boston MA, January, 1985.

3/ National Cooperative Highway Research Program, NCHRP Report 133, Procedures for Estimating Highway User Costs, Air Pollution, and Noise Effects, 1972.

4/ EPA, Guidelines for Air Quality Maintenance Planning and Analysis Volume 9 (Revised): Evaluating Indirect Sources, Second Printing, EPA-450/4-78-001, Research Triangle Park, NC September 1978.

to estimate queue length. A summary of the highest concentrations predicted by CALQ3 is included at the end of this Appendix. More detailed computer output is available upon request.

Multiple receptors were used at each intersection and were placed based on land use considerations, i.e., where the public has access and is expected to be for periods of time. Receptors are placed at least 3 meters from the edge of the nearest travel lane so that they are not within the roadway mixing cell, and a receptor height of 1.8 meters is assumed. Scaled maps of land use and receptor locations are shown in Figures 1 through 4 of the main body of the report.

The analysis utilized peak 1-hour and 8-hour traffic volumes. Based on the 1990 Build Garage Option 3 total volumes entering an intersection, the peak hour is in the morning at Washington Street/Kneeland Street and is in the afternoon at the other three locations. Peak 8-hour volumes were estimated by applying the reduction factor of 0.78, derived from the traffic counts shown in Table 1, to the peak hour volumes.

Traffic volume data for the intersections represent peak conditions during a weekday and are presented in the traffic sections of this report. Intersection geometry is shown in Figures 1 through 4 in the main body of the report. Signal timing for the intersections is from field measurements and these data are summarized in Tables 9 through 12.

travel from the middle of the center level to the exit at 4.5 m/s (10 mph). For the three options the distances (times) are 800 m, 480 m, and 850 m (178 s, 107 s, and 189 s). Finally, the vehicle passes through the exit gate in 10 seconds (assuming two exit card readers, one of which is reversible, during the peak hour). Total vehicle operating times for the three options are 203 s, 132 s, and 214 s.

The peak hour traffic for the garage will occur in the afternoon when a total of 290 cars either exit or enter in one hour. For the peak 8-hour period, an average of 226 vehicles per hour will access the garage. Multiplying traffic volumes by emission rates and by garage operating times yield the CO emission rates for the garage as a whole shown in Table 2.

TABLE 2
PARKING GARAGE CO EMISSIONS INVENTORY (g/s)

	Garage Options		
	1	2	3
Peak 1-Hour	2.66	1.73	2.80
Peak 8-Hour	1.35	0.88	1.42

These emissions will be released from the sidewall openings in the garage that provide nature ventilation. The number of floors and dimensions of the parking structure differ for the three options. The total sidewall areas for the three options are 1,050 m^2, 975 m^2, and 1,500 m^2, respectively. Assuming DEQE worst case (lowest) wind speeds of 1.0 m/s (1-hour) and 1.6 m/s (8-hour) for nature ventilation of the garage, the CO concentration in the air leaving the garage is calculated and shown in Table 3. Note that these numbers do not reflect the addition of existing background concentrations of CO.

TABLE 3
UNDILUTED CO CONCENTRATIONS IN AIR LEAVING
THE PARKING GARAGE

	CO (mg/m^3) Garage Options			CO (ppm) Garage Options		
	1	2	3	1	2	3
Peak 1-Hour	2.53	1.77	1.87	2.2	1.5	1.6
Peak 8-Hour	0.80	0.56	0.59	0.7	0.5	0.5

These concentrations will be diluted once the air leaves the garage. Some of the sensitive receptors in this analysis are, however, directly adjacent to the garage sites. Thus, as a conservative approach, the undiluted impacts were added to the modeling results for the intersection analysis to obtain total CO concentrations at the sensitive receptors.

CALCULATION OF MOTOR VEHICLE CO EMISSION RATES

The EPA MOBILE3 computer program was used to generate all CO emission rates used in this analysis. Roadway CO emission rates used in this study are based on the MOBILE3 default national motor vehicle mix (see Table 4) an average December temperature of 33°F, and the 1985 Massachusetts registration distributions for seven vehicle types (see Table 5). The MOBILE3 default national cold/hot start mix (presented in Table 6) was used for determining roadway emissions during the peak 8-hour period. A mix with a higher cold start percentage for the evening rush hour was used to represent the peak 1-hour period. Emission rates are based on peak hour travel speeds for the vehicles approaching each intersection as estimated from field surveys. These speeds represent the free flow condition between intersections. Excess emissions due to idling in queues are also calculated by MOBILE3 (see Table 8). Emission rates used in this analysis assume a Statewide Inspection and Maintenance Program starting in 1983,

with a 13 percent stringency factor and no mechanic training for pre-1981 model years, and an idle test with cutpoints at 1.2 percent CO and 220 ppm HC for 1981 and later model years. Table 7 presents the composite CO emission rates for the peak 1-hour and 8-hour periods while Table 8 gives the idle emission rates used in the analysis (based on a 5 mph speed). The complete MOBILE3 output is found later in this Appendix.

TABLE 4
NATIONWIDE AVERAGE MOTOR VEHICLE MIX BY TYPE

Vehicle Type	Percent of VMT 1990
Light-Duty Gasoline Vehicles (LDGV)	64.2
Light-Duty Gasoline Trucks	
0-6000 lb GVW* (LDGT1)	11.9
Over 6000 lb GVW (LDGT2)	8.9
Heavy-Duty Gasoline Trucks (HDGV)	3.5
Light-Duty Diesel Vehicles (LDDV)	4.6
Light-Duty Diesel Trucks (LDDT)	2.1
Heavy-Duty Diesel Trucks (HDDT)	4.1
Motorcycles (MC)	0.7
Total Percent	100.0
Medium- and Heavy-Duty Trucks (HDDT + HDGV + LDGT2)	16.5

* Gross vehicle weight.

TABLE 5
1985 MASSACHUSETTS VEHICLE AGE DISTRIBUTIONS (percent)

Age (Years)	LDGV, LDDV	LDGT1, LDGT2, LDDT	HDGV, HDDV
1	7.07	6.3	4.2
2	10.13	6.9	7.2
3	8.51	5.8	5.4
4	7.74	5.9	5.3
5	7.96	12.6	8.4
6	8.36	9.8	10.0
7	8.40	8.8	8.2
8	7.88	6.5	6.2
9	6.65	4.6	4.8
10	6.00	6.6	6.4
11	6.00	5.7	6.4
12	5.00	4.6	7.8
13	3.00	3.4	3.8
14	2.00	2.7	3.2
15	1.50	2.2	3.0
16	1.10	1.8	2.4
17	0.90	1.7	2.1
18	0.70	1.6	1.9
19	0.60	1.4	1.8
20+			
0.			
50			
1.1	1.5		
Total	100.0	100.0	100.0

Source: Massachusetts Department of Environmental Quality Engineering.

TABLE 6
COLD/HOT START MIX FOR MOTOR VEHICLE EMISSIONS

	Intersection Analysis 1-Hour	Intersection Analysis 8-Hour
Cold Start	50.0%	20.6%
Hot Start	10.0%	27.3%
Hot Stabilized	40.0%	52.1%
Total	100.0%	100.0%

1468/786/wpr

TABLE 7
COMPOSITE CO EMISSION RATES

Approach Speed (mph)	Roadway Approaches	Emissions (grams/mile) 1984	1990
Peak 1-Hr. Period			
20	All Surface Streets	91.53	48.65
45	Mass. Turnpike	35.59	16.94
Peak 8-Hr. Period			
25	All Surface Streets	46.44	24.62
55	Mass. Turnpike	20.11	8.70

TABLE 8
IDLE EMISSION RATES FOR CO*
(grams/minute)

Time Period	1990
Peak 1-Hour	9.76
Peak 8-Hour	6.35

* Idle emission rates are derived from MOBILE3 estimates for 5 mph. This approach is used to ensure the effects of cold and hot start engines are included in the idle emission rates.

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MOBILE SOURCE EMISSIONS - NEMCH TRANSPORATATION MASTER PLAN

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1975
LAST MODEL YEAR COVERED:	1990
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1984 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0 ALTITUDE: 500. FT

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	20.0	20.0	20.0		20.0	20.0	20.0	20.0	20.0	
VMT MIX:	0.663	0.134	0.090		0.035	0.019	0.005	0.047	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	82.90	123.40	137.07	128.91	187.51	1.47	1.95	14.90	51.07	91.53

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1984 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6 ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	25.0	25.0	25.0		25.0	25.0	25.0	25.0	25.0	
VMT MIX:	0.663	0.134	0.090		0.035	0.019	0.005	0.047	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	39.86	60.05	67.19	62.93	147.13	1.02	1.35	11.78	25.25	46.44

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1990 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0 ALTITUDE: 500. FT

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	
VMT MIX:	0.641	0.119	0.089		0.035	0.046	0.021	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	102.59	171.91	187.29	178.50	311.18	4.01	4.62	33.15	210.52	117.12

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1990 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 50.0 / 10.0 / 50.0 ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	20.0	20.0	20.0		20.0	20.0	20.0	20.0	20.0	
VMT MIX:	0.641	0.119	0.089		0.035	0.046	0.021	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	46.06	68.66	68.86	68.75	108.08	1.51	1.74	12.46	49.37	48.65

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1990 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6 ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	
VMT MIX:	0.641	0.119	0.089		0.035	0.046	0.021	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	61.99	105.65	116.21	110.18	311.18	3.48	4.05	33.15	129.71	76.22

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1990 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6 ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	25.0	25.0	25.0		25.0	25.0	25.0	25.0	25.0	
VMT MIX:	0.641	0.119	0.089		0.035	0.046	0.021	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	22.01	32.94	32.88	32.91	84.81	1.03	1.20	9.85	24.26	24.62

MOBILE SOURCE EMISSIONS - NEMCH TRANSPORATATION MASTER PLAN

I/M PROGRAM SELECTED:

START YEAR (JANUARY 1):	1983
PRE-1981 MYR STRINGENCY RATE:	13%
MECHANIC TRAINING PROGRAM?:	NO
FIRST MODEL YEAR COVERED:	1975
LAST MODEL YEAR COVERED:	1990
VEHICLE TYPES COVERED:	LDGV, LDGT1, LDGT2
1981 & LATER MYR TEST TYPE:	IDLE
1981 & LATER MYR TEST CUTPOINTS:	1.2% ICO / 220 PPM IHC

TOTAL HC EMISSION FACTORS INCLUDE EVAPORATIVE HC EMISSION FACTORS.

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1984 — I/M PROGRAM: YES — AMBIENT TEMP: 33.0 (F) — REGION: LOW
ANTI-TAM. PROGRAM: NO — OPERATING MODE: 50.0 / 10.0 / 50.0 — ALTITUDE: 500. FT

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	45.0	45.0	45.0		45.0	45.0	45.0	45.0	45.0	
VMT MIX:	0.663	0.134	0.090		0.035	0.019	0.005	0.047	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	31.81	46.13	49.03	47.30	96.67	0.72	0.95	7.24	21.75	35.59

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1984 — I/M PROGRAM: YES — AMBIENT TEMP: 33.0 (F) — REGION: LOW
ANTI-TAM. PROGRAM: NO — OPERATING MODE: 20.6 / 27.3 / 20.6 — ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	55.0	55.0	55.0		55.0	55.0	55.0	55.0	55.0	
VMT MIX:	0.663	0.134	0.090		0.035	0.019	0.005	0.047	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	15.73	23.51	25.15	24.17	109.00	0.65	0.86	7.46	11.44	20.11

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1990 — I/M PROGRAM: YES — AMBIENT TEMP: 33.0 (F) — REGION: LOW
ANTI-TAM. PROGRAM: NO — OPERATING MODE: 50.0 / 10.0 / 50.0 — ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	45.0	45.0	45.0		45.0	45.0	45.0	45.0	45.0	
VMT MIX:	0.641	0.119	0.089		0.035	0.046	0.021	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO.	15.48	22.45	21.56	22.07	55.72	0.73	0.84	6.06	20.69	16.94

USER SUPPLIED VEH REGISTRATION DISTRIBUTIONS.

CAL. YEAR: 1990 I/M PROGRAM: YES AMBIENT TEMP: 33.0 (F) REGION: LOW
ANTI-TAM. PROGRAM: NO OPERATING MODE: 20.6 / 27.3 / 20.6 ALTITUDE: 500. FT.

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPEEDS:	55.0	55.0	55.0		55.0	55.0	55.0	55.0	55.0	
VMT MIX:	0.641	0.119	0.089		0.035	0.046	0.021	0.041	0.007	
COMPOSITE EMISSION FACTORS (GM/MILE)										
EXHAUST CO:	6.39	9.89	9.25	9.62	62.83	0.66	0.76	6.24	10.73	8.70

JOB: WASHINGTON/KNEELAND RUN: CASE 1 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321 CM VD = 0.0 CM/S AM0 = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1 WASHINGTON NB FREE	53	56.	53.	556	500	360	AG	820	48 6	0.0	22.2	0.0	0.0
2. WASHINGTON 1WAY FREE	53.	56.	53	-444	500.	180	AG	613	48 6	0 0	12.1	0.0	0 0
3 KNEELAND FREE	-447.	56.	553.	56.	1000.	90.	AG	1541	48 6	0.0	22.2	0.0	0.0
4. WASHINGTON NB Q	51.	71	51.	95	24	360.	AG	1661	100.0	0.0	13.3	0.43	3 4
5. KNEELAND EB Q	71.	59	107.	59.	36	90.	AG	2334	100.0	0.0	13.3	0.80	5.6
6. KNEELAND WB Q	36.	50.	-6	50.	42	270	AG	1930	100.0	0.0	13.3	0 77	6.3

JOB: WASHINGTON/KNEELAND RUN: CASE 1 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS DENTAL	29	73	1 8	6 0
2. US DEPT OF AGRICULTU	87.	77	1 8	6.5
3. THU-NGA RESTAURANT	71	36	1 8	5.3
4 LENA'S SUB SHOP	37	37.	1 8	7 1

JOB: WASHINGTON/KNEELAND RUN: CASE 2 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON NB FREE	53.	56.	53.	556.	500.	360.	AG	965	48.6	0.0	22.2	0.0	0.0
2. WASHINGTON 1WAY FREE	53	56.	53.	-444	500.	180.	AG	613	48.6	0.0	12.1	0.0	0.0
3. KNEELAND FREE	-447	56.	553.	56.	1000.	90	AG	1662.	48.6	0.0	22.2	0.0	0.0
4. WASHINGTON NB Q	51.	71	51.	95	24	360	AG	1661	100.0	0.0	13.3	0.44	3.4
5. KNEELAND EB Q	71.	59.	107.	59	36.	90	AG	2334	100.0	0.0	13.3	0.82	5.9
6. KNEELAND WB Q	36.	50.	-12.	50.	48.	270	AG	1930	100.0	0.0	13.3	0.85	8.0

JOB: WASHINGTON/KNEELAND RUN: CASE 2 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1 TUFTS DENTAL	29	73	1.8	6.3
2 US DEPT OF AGRICULTU	87	77	1.8	6.6
3 THU-NGA RESTAURANT	71	36	1.8	5.5
4 LENA'S SUB SHOP	37	37	1.8	7.6

JOB: WASHINGTON/KNEELAND RUN: CASE 3 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VO = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON NB FREE	53.	56.	53.	556.	500.	360.	AG	870.	48.6	0.0	22.2	0.0	0.0
2. WASHINGTON 1WAY FREE	53.	56.	53.	-444.	500.	180.	AG	613.	48.6	0.0	12.1	0.0	0.0
3. KNEELAND FREE	-447.	56.	553.	56.	1000.	90.	AG	1589.	48.6	0.0	22.2	0.0	0.0
4. WASHINGTON NB Q	51.	71.	51.	95.	24.	360.	AG	1661.	100.0	0.0	13.3	0.44	3.4
5. KNEELAND EB Q	71.	59.	107.	59.	36.	90.	AG	2334.	100.0	0.0	13.3	0.81	5.7
6. KNEELAND WB Q	36.	50.	-6.	50.	42.	270.	AG	1930.	100.0	0.0	13.3	0.80	6.8

JOB: WASHINGTON/KNEELAND RUN: CASE 3 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS DENTAL	29.	73.	1.8	6.1
2. US DEPT OF AGRICULTU	87.	77.	1.8	6.5
3. THU-NGA RESTAURANT	71.	36.	1.8	5.4
4. LENA'S SUB SHOP	37.	37.	1.8	7.2

JOB: WASHINGTON/KNEELAND RUN: CASE 4 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321 CM VO = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON NB FREE	53.	56.	53.	556.	500.	360	AG	821.	48.6	0.0	22.2	0.0	0.0
2. WASHINGTON 1WAY FREE	53.	56.	53.	-444.	500.	180.	AG	613.	48.6	0.0	12.1	0.0	0.0
3. KNEELAND FREE	-447.	56	553.	56	1000.	90.	AG	1550.	48.6	0.0	22.2	0.0	0.0
4. WASHINGTON NB Q	51.	71	51.	95	24	360.	AG	1661.	100.0	0.0	13.3	0.44	3.4
5. KNEELAND EB Q	71.	59.	107.	59	36.	90.	AG	2334.	100.0	0.0	13.3	0.81	5.7
6. KNEELAND WB Q	36.	50.	-6.	50.	42.	270.	AG	1930.	100.0	0.0	13.3	0.77	6.3

JOB: WASHINGTON/KNEELAND RUN: CASE 4 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS DENTAL	29	73	1.8	6.0
2. US DEPT OF AGRICULTU	87.	77	1.8	6.5
3. THU-NGA RESTAURANT	71	36	1.8	5.3
4. LENA'S SUB SHOP	37	37	1.8	7.1

JOB: WASHINGTON/KNEELAND RUN: CASE 1 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321 CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON NB FREE	53	56	53.	556	500.	360	AG	640	24 6	0.0	22 2	0.0	0.0
2. WASHINGTON 1WAY FREE	53.	56.	53	-444.	500	180	AG	478	24 6	0.0	12 1	0 0	0.0
3. KNEELAND FREE	-447	56	553	56	1000	90	AG	1202	24 6	0.0	22.2	0 0	0 0
4. WASHINGTON NB Q	51	71.	51.	89	18	360	AG	1080	100.0	0 0	13 3	0 34	2.7
5 KNEELAND EB Q	71	59.	95.	59	24.	90	AG	1518	100.0	0.0	13.3	0.63	3 6
6. KNEELAND WB Q	36.	50.	6	50.	30.	270	AG	1256	100.0	0.0	13 3	0.60	4.3

JOB: WASHINGTON/KNEELAND RUN: CASE 1 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1 TUFTS DENTAL	29	73	1.8	2.0
2 US DEPT OF AGRICULTU	87	77	1.8	2.4
3 THU-NGA RESTAURANT	71	36	1.8	2.0
4 LENA'S SUB SHOP	37	37	1.8	2 6

JOB: WASHINGTON/KNEELAND RUN: CASE 2 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON NB FREE	53.	56.	53.	556.	500.	360.	AG	753.	24.6	0.0	22.2	0.0	0.0
2. WASHINGTON 1WAY FREE	53.	56.	53.	-444.	500.	180.	AG	478.	24.6	0.0	12.1	0.0	0.0
3. KNEELAND FREE	-447.	56.	553.	56.	1000.	90.	AG	1296.	24.6	0.0	22.2	0.0	0.0
4. WASHINGTON NB Q	51.	71.	51.	89.	18.	360.	AG	1080.	100.0	0.0	13.3	0.34	2.7
5. KNEELAND EB Q	71.	59.	95.	59.	24.	90.	AG	1518.	100.0	0.0	13.3	0.64	3.8
6. KNEELAND WB Q	36.	50.	6.	50.	30.	270.	AG	1256.	100.0	0.0	13.3	0.67	5.0

JOB: WASHINGTON/KNEELAND RUN: CASE 2 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS DENTAL	29.	73.	1.8	2.0
2. US DEPT OF AGRICULTU	87.	77.	1.8	2.5
3. THU-NGA RESTAURANT	71.	36.	1.8	2.0
4. LENA'S SUB SHOP	37.	37.	1.8	2.7

JOB: WASHINGTON/KNEELAND RUN: CASE 3 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON NB FREE	53.	56.	53.	556.	500.	360.	AG	679.	24.6	0.0	22.2	0.0	0.0
2. WASHINGTON 1WAY FREE	53.	56.	53.	-444.	500.	180.	AG	478.	24.6	0.0	12.1	0.0	0.0
3. KNEELAND FREE	-447.	56.	553.	56.	1000.	90.	AG	1239.	24.6	0.0	22.2	0.0	0.0
4. WASHINGTON NB Q	51.	71.	51.	89.	18.	360.	AG	1080.	100.0	0.0	13.3	0.34	2.7
5. KNEELAND EB Q	71.	59.	95.	59.	24.	90.	AG	1518.	100.0	0.0	13.3	0.63	3.7
6. KNEELAND WB Q	36.	50.	6.	50.	30.	270.	AG	1256.	100.0	0.0	13.3	0.62	4.5

JOB: WASHINGTON/KNEELAND RUN: CASE 3 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS DENTAL	29.	73.	1.8	2.0
2. US DEPT OF AGRICULTU	87.	77.	1.8	2.5
3. THU-NGA RESTAURANT	71.	36.	1.8	2.0
4. LENA'S SUB SHOP	37.	37.	1.8	2.7

JOB: WASHINGTON/KNEELAND RUN: CASE 4 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321 CM VO = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON NB FREE	53.	56.	53.	556.	500.	360.	AG	640.	24.6	0.0	22.2	0.0	0.0
2. WASHINGTON 1WAY FREE	53.	56.	53.	-444.	500.	180.	AG	478.	24.6	0.0	12.1	0.0	0.0
3. KNEELAND FREE	-447.	56.	553.	56.	1000.	90.	AG	1209.	24.6	0.0	22.2	0.0	0.0
4. WASHINGTON NB Q	51.	71.	51.	89.	18.	360.	AG	1080.	100.0	0.0	13.3	0.34	2.7
5. KNEELAND EB Q	71.	59.	95.	59.	24.	90.	AG	1518.	100.0	0.0	13.3	0.63	3.7
6. KNEELAND WB Q	36.	50.	6.	50.	30.	270.	AG	1256.	100.0	0.0	13.3	0.60	4.3

JOB: WASHINGTON/KNEELAND RUN: CASE 4 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1 TUFTS DENTAL	29	73	1.8	2.0
2 US DEPT OF AGRICULTU	87	77.	1.8	2.4
3 THU-NGA RESTAURANT	71	36	1.8	2.0
4 LENA'S SUB SHOP	37	37.	1.8	2.6

EPA REGION I CAL Q3 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: WASHINGTON/OAK RUN: CASE 1 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	LINK COORDINATES (M) X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	54.	-428.	54.	572.	1000.	360.	AG	840.	48.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72.	1000.	90.	AG	371.	48.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	50.	82.	49.	88.	6.	360.	AG	942.	100.0	0.0	13.3	0.07	0.5
4. WASHINGTON NB Q	69.	64.	59.	46.	18.	180.	AG	942.	100.0	0.0	13.3	0.28	2.3
6. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	86.	100.0	0.0	10.0	0.52	3.9

EPA REGION I CAL Q3 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: WASHINGTON/OAK RUN: CASE 1 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	COORDINATES (M) X	Y	Z	TOTAL + AMB (PPM)
1. NEMCH	34.	89.	1.8	2.3
2. NE CORNER	72.	84.	1.8	2.7
3. SE CORNER	74.	59.	1.8	3.0
4. QUINCY TOWERS	32.	54.	1.8	2.3

JOB: WASHINGTON/OAK RUN: CASE 2 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	54.	-428.	54.	572.	1000.	360.	AG	1014.	48.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72.	1000.	90.	AG	381.	48.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	60.	82.	49.	94.	12.	360.	AG	942.	100.0	0.0	13.3	0.13	1.1
4. WASHINGTON NB Q	59.	64.	58.	46.	18.	180.	AG	942.	100.0	0.0	13.3	0.29	2.3
5. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	86.	100.0	0.0	10.0	0.53	4.0

JOB: WASHINGTON/OAK RUN: CASE 2 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NEMCH	34.	89.	1.8	3.1
2. NE CORNER	72.	84.	1.8	3.0
3. SE CORNER	74.	59.	1.8	3.3
4. QUINCY TOWERS	32.	54	1.8	2.6

JOB: WASHINGTON/OAK RUN: CASE 3 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	54.	-428.	54.	572.	1000.	360.	AG	1008.	48.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72.	1000.	90.	AG	373.	48.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	50.	82.	49.	88.	6.	360.	AG	942.	100.0	0.0	13.3	0.87	0.6
4. WASHINGTON NB Q	59.	64.	59.	46.	18.	180.	AG	942.	100.0	0.0	13.3	0.35	2.8
5. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	86.	100.0	0.0	10.0	0.53	4.0

JOB: WASHINGTON/OAK RUN: CASE 3 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NEMCH	34.	89.	1.8	2.5
2. NE CORNER	72.	84.	1.8	3.0
3. SE CORNER	74.	59.	1.8	3.1
4. QUINCY TOWERS	32.	54.	1.8	2.5

JOB: WASHINGTON/OAK RUN: CASE 4 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	54.	-428.	54.	572.	1000.	360.	AG	861.	48.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72.	1000.	90.	AG	371.	48.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	60.	82.	49.	88.	6.	368.	AG	942.	100.0	0.0	13.3	0.07	0.5
4. WASHINGTON NB Q	59.	64.	59.	46.	18.	180.	AG	942.	100.0	0.0	13.3	0.29	2.3
5. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	86.	100.0	0.0	10.0	0.52	3.9

JOB: WASHINGTON/OAK RUN: CASE 4 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NEMCH	34.	89.	1.8	2.3
2. NE CORNER	72.	84.	1.8	2.7
3. SE CORNER	74.	59.	1.8	3.0
4. QUINCY TOWERS	32.	54.	1.8	2.3

JOB: WASHINGTON/OAK RUN: CASE 1 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
	LINK COORDINATES (M)												
1. WASHINGTON FREE	54.	-428.	54.	572.	1000.	360.	AG	655.	24.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72.	1000.	90.	AG	289.	24.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	50.	82.	49.	88.	6.	360.	AG	613	100.0	0.0	13.3	0.05	0.4
4. WASHINGTON NB Q	58.	64.	59.	52.	12.	180.	AG	613.	100.0	0.0	13.3	0.22	1.8
5. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	86.	100.0	0.0	10.0	0.41	3.1

JOB: WASHINGTON/OAK RUN: CASE 1 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
	COORDINATES (M)			
1. NEMCH	34.	89.	1.8	0.8
2. NE CORNER	72.	84.	1.8	0.8
3. SE CORNER	74.	59.	1.8	1.0
4. QUINCY TOWERS	32.	54.	1.8	0.6

JOB: WASHINGTON/OAK RUN: CASE 2 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	54.	-428.	54.	572.	1000.	360.	AG	791.	24.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72	1000.	90.	AG	297.	24.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	50.	82.	49.	88.	6.	360.	AG	613	100.0	0.0	13.3	0.10	0.8
4. WASHINGTON NB Q	59.	64.	59.	52.	12.	180.	AG	613	100.0	0.0	13.3	0.22	1.8
5. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	86.	100.0	0.0	10.0	0.41	3.1

JOB: WASHINGTON/OAK RUN: CASE 2 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NEMCH	34.	89.	1.8	0.8
2. NE CORNER	72.	84	1.8	0.8
3 SE CORNER	74.	59.	1.8	1.1
4. QUINCY TOWERS	32.	54.	1.8	0.7

JOB: WASHINGTON/OAK RUN: CASE 3 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	54	-428.	54.	572.	1000.	360.	AG	786.	24.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72.	1000.	90.	AG	291.	24.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	50.	82.	49.	88.	6.	360.	AG	613.	100.0	0.0	13.3	0.06	0.5
4. WASHINGTON NB Q	59.	64.	59.	46.	18.	180.	AG	613.	100.0	0.0	13.3	0.27	2.2
5. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	88.	100.0	0.0	10.0	0.41	3.1

JOB: WASHINGTON/OAK RUN: CASE 3 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X (M)	Y (M)	Z (M)	TOTAL + AMB (PPM)
1. NEMCH	34.	89.	1.8	0.8
2. NE CORNER	72.	84.	1.8	0.9
3. SE CORNER	74.	59.	1.8	1.2
4. QUINCY TOWERS	32.	54.	1.8	0.9

JOB: WASHINGTON/OAK RUN: CASE 4 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	54.	-428.	54.	572.	1000.	360.	AG	672.	24.6	0.0	22.2	0.0	0.0
2. OAK FREE	-446.	72.	554.	72.	1000.	90.	AG	289.	24.6	0.0	13.3	0.0	0.0
3. WASHINGTON SB Q	50.	82.	49.	88.	6.	360.	AG	613.	100.0	0.0	13.3	0.05	0.4
4. WASHINGTON NB Q	59.	64.	59.	52.	12.	180.	AG	613.	100.0	0.0	13.3	0.22	1.8
5. OAK EB Q	41.	71.	17.	71.	24.	270.	AG	86.	100.0	0.0	10.0	0.41	3.1

JOB: WASHINGTON/OAK RUN: CASE 4 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NEMCH	34.	89.	1.8	0.8
2. NE CORNER	72.	84.	1.8	0.8
3. SE CORNER	74.	69.	1.8	1.1
4. QUINCY TOWERS	32.	54.	1.8	0.6

JOB: WASHINGTON/HERALD RUN: CASE 1 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 ZO = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	954.	48.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1731.	48.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102.	565.	102.	1000.	90.	DP	13475.	16.9	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	113.	66.	42.	90.	AG	707.	100.0	0.0	10.0	0.74	7.0
5. WASHINGTON NB Q	65.	51.	65.	27.	24.	180.	AG	1728.	100.0	0.0	13.3	0.35	3.2
6. HERALD EB Q	55.	60.	25.	60.	30.	270.	AG	2121.	100.0	0.0	17.0	0.52	4.9

JOB: WASHINGTON/HERALD RUN: CASE 1 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	8.8
2. NE CORNER	72.	74.	1.8	9.1
3. PARKING LOT	77.	49.	1.8	11.5
4. TERADYNE CORP	38.	44.	1.8	8.8

EPA REGION I CALQ3 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: WASHINGTON/HERALD RUN: CASE 2 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321 CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	965.	48.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1737.	48.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102.	565.	102.	1000.	90.	DP	13475.	16.9	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	119.	66.	48.	90.	AG	707.	100.0	0.0	10.0	0.75	7.2
5. WASHINGTON NB Q	65.	51.	65.	27.	24.	180.	AG	1728.	100.0	0.0	13.3	0.35	3.3
6. HERALD EB Q	55.	60.	25.	60.	30.	270.	AG	2121.	100.0	0.0	17.0	0.52	4.9

EPA REGION I CALQ3 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: WASHINGTON/HERALD RUN: CASE 2 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	8.8
2. NE CORNER	72.	74.	1.8	9.1
3. PARKING LOT	77.	49.	1.8	11.6
4. TERADYNE CORP	38.	44.	1.8	8.8

JOB: WASHINGTON/HERALD RUN: CASE 3 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
	LINK COORDINATES (M)												
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	966.	48.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1739.	48.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102.	565.	102.	1000.	90.	DP	13475.	16.9	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	119.	66.	48.	90.	AG	707.	100.0	0.0	10.0	0.75	7.2
5. WASHINGTON NB Q	65.	51.	65.	27.	24.	180.	AG	1728.	100.0	0.0	13.3	0.35	3.3
6. HERALD EB Q	55.	60.	25.	60.	30.	270.	AG	2121.	100.0	0.0	17.0	0.52	4.9

JOB: WASHINGTON/HERALD RUN: CASE 3 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	COORDINATES (M) X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	8.8
2. NE CORNER	72.	74.	1.8	9.1
3. PARKING LOT	77.	49.	1.8	11.6
4. TERADYNE CORP	38.	44.	1.8	8.8

EPA REGION I CAL03 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: WASHINGTON/HERALD RUN: CASE 4 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	1151.	48.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1814.	48.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102	565.	102.	1000.	90.	DP	13475.	16.9	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	113.	66.	42.	90.	AG	707.	100.0	0.0	10.0	0.74	7.0
5. WASHINGTON NB Q	65.	51.	65.	21.	30.	180.	AG	1728.	100.0	0.0	13.3	0.53	4.9
6. HERALD EB Q	55.	60.	25.	60.	30.	270.	AG	2121.	100.0	0.0	17.0	0.52	4.9

EPA REGION I CAL03 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: WASHINGTON/HERALD RUN: CASE 4 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	9.4
2. NE CORNER	72.	74.	1.8	9.5
3. PARKING LOT	77.	49.	1.8	11.9
4. TERADYNE CORP	38.	44.	1.8	9.0

JOB: WASHINGTON/HERALD RUN: CASE 1 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	744.	24.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1360.	24.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102.	565.	102.	1000.	90.	DP	10511.	8.7	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	107.	66.	36.	90.	AG	460.	100.0	0.0	10.0	0.58	5.4
5. WASHINGTON NB Q	65.	51.	65.	33.	18.	180.	AG	1124.	100.0	0.0	13.3	0.27	2.5
6. HERALD EB Q	55.	60.	31.	60.	24.	270.	AG	1380.	100.0	0.0	17.0	0.41	3.8

JOB: WASHINGTON/HERALD RUN: CASE 1 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	3.3
2. NE CORNER	72.	74.	1.8	2.8
3. PARKING LOT	77.	49.	1.8	3.9
4. TERADYNE CORP	38.	44.	1.8	3.2

JOB: WASHINGTON/HERALD RUN: CASE 2 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	753.	24.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1355.	24.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102.	565.	102.	1000.	90.	DP	10511.	8.7	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	107.	66.	36.	90.	AG	460.	100.0	0.0	10.0	0.59	5.5
5. WASHINGTON NB Q	65.	51.	65.	33.	18.	180.	AG	1124.	100.0	0.0	13.3	0.28	2.5
6. HERALD EB Q	55.	60.	31.	60.	24.	270.	AG	1380.	100.0	0.0	17.0	0.41	3.8

JOB: WASHINGTON/HERALD RUN: CASE 2 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	COORDINATES (M) X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	3.3
2. NE CORNER	72.	74.	1.8	2.8
3. PARKING LOT	77.	49.	1.8	3.9
4 TERADYNE CORP	38.	44.	1.8	3.2

JOB: WASHINGTON/HERALD RUN: CASE 3 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	753.	24.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1356.	24.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102.	565.	102.	1000.	90.	DP	10511.	8.7	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	107.	66.	36.	90.	AG	460.	100.0	0.0	10.0	0.58	5.5
5. WASHINGTON NB Q	65.	51.	65.	33.	18.	180.	AG	1124.	100.0	0.0	13.3	0.28	2.5
6. HERALD EB Q	55.	60.	31.	60.	24.	270.	AG	1380.	100.0	0.0	17.0	0.41	3.8

JOB: WASHINGTON/HERALD RUN: CASE 3 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	3.3
2. NE CORNER	72.	74.	1.8	2.8
3. PARKING LOT	77.	49.	1.8	3.9
4. TERADYNE CORP	38.	44.	1.8	3.2

JOB: WASHINGTON/HERALD RUN: CASE 4 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. WASHINGTON FREE	65.	-440.	65.	560.	1000.	360.	AG	897.	24.6	0.0	13.3	0.0	0.0
2. HERALD FREE	-435.	60.	565.	60.	1000.	90.	AG	1415.	24.6	0.0	17.0	0.0	0.0
3. MASS PIKE FREE	-435.	102.	665.	102.	1000.	90.	DP	10511.	8.7	-6.0	34.0	0.0	0.0
4. HERALD WB Q	71.	66.	107.	66.	36.	90.	AG	460.	100.0	0.0	10.0	0.58	5.4
5. WASHINGTON NB Q	65.	51.	65.	27.	24.	180.	AG	1124.	100.0	0.0	13.3	0.42	3.8
6. HERALD EB Q	55.	60.	31.	60.	24.	270.	AG	1380.	100.0	0.0	17.0	0.41	3.8

JOB: WASHINGTON/HERALD RUN: CASE 4 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. NW CORNER	51.	73.	1.8	3.4
2. NE CORNER	72.	74.	1.8	2.9
3. PARKING LOT	77.	49.	1.8	4.0
4. TERADYNE CORP	38.	44.	1.8	3.4

JOB: HARRISON/OAK RUN: CASE 1 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1 HARRISON SB FREE	58.	-434	58.	566.	1000.	360	AG	526	48.6	0.0	10.0	0.0	0.0
2. OAK EB FREE	-442.	66.	558.	66.	1000	90	AG	313.	48.6	0.0	10.0	0.0	0.0
3. OAK EB Q	48.	67.	-17.	65.	66.	269	AG	1100.	100.0	0.0	10.0	0.64	10.1

JOB: HARRISON/OAK RUN: CASE 1 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	COORDINATES (M) X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS VET	45	91	1.8	1.9
2. TUFTS UNIV	71	80	1.8	2.8
3 TAI LOY MARKET	76	50	1.8	2.3
4. RAY'S SUB SHOP	42	55	1.8	3.5

JOB: HARRISON/OAK RUN: CASE 2 1-HOUR

I SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II LINK VARIABLES

LINK DESCRIPTION	LINK COORDINATES (M) X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. HARRISON SB FREE	58.	-434	58.	566	1000	360	AG	497	48.6	0.0	10.0	0.0	0.0
2 OAK EB FREE	-442	66.	558.	66	1000.	90	AG	370.	48.6	0.0	10.0	0.0	0.0
3 OAK EB Q	49	67.	-17.	65.	66	269	AG	1100	100.0	0.0	10.0	0.76	10.1

JOB: HARRISON/OAK RUN: CASE 2 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	COORDINATES (M) X	Y	Z	TOTAL + AMB (PPM)
1 TUFTS VET	45	91	1.8	2.0
2 TUFTS UNIV	71	80	1.8	2.8
3 TAI LOY MARKET	76	50	1.8	2.3
4 RAY'S SUB SHOP	42	55	1.8	3.6

JOB: HARRISON/OAK RUN: CASE 3 1-HOUR

I. SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VO = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	*	X1	Y1	X2	Y2	*	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. HARRISON SB FREE	*	58	-434	58.	566.	*	1000	360.	AG	536	48.6	0.0	10.0	0.0	0.0
2. OAK EB FREE	*	-442.	66	558.	66.	*	1000.	90.	AG	414.	48.6	0.0	10.0	0.0	0.0
3. OAK EB Q	*	49	67	-17.	66.	*	66	269.	AG	1100.	100.0	0.0	10.0	0.85	10.1

JOB: HARRISON/OAK RUN: CASE 3 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	*	X	Y	Z	*	TOTAL + AMB (PPM)
1. TUFTS VET	*	45	91.	1.8	*	2.0
2. TUFTS UNIV	*	71	80.	1.8	*	3.0
3. TAI LOY MARKET	*	76	50.	1.8	*	2.4
4. RAY'S SUB SHOP	*	42	55.	1.8	*	3.6

EPA REGION I CAL03 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: HARRISON/OAK RUN: CASE 4 1-HOUR

I SITE VARIABLES

U = 1.0 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321 CM VO = 0.0 CM/S AMB = 0.0 PPM

II LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. HARRISON SB FREE	58.	-434.	58.	566.	1000.	360.	AG	539.	48.6	0.0	10.0	0.0	0.0
2. OAK EB FREE	-442.	66.	558.	66.	1000.	90.	AG	313.	48.6	0.0	10.0	0.0	0.0
3. OAK EB Q	49.	67.	-17.	65.	66.	269.	AG	1100.	100.0	0.0	10.0	0.64	10.1

EPA REGION I CAL03 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: HARRISON/OAK RUN: CASE 4 1-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1 TUFTS VET	45	91	1.8	1.9
2 TUFTS UNIV	71	80	1.8	2.8
3 TAI LOY MARKET	76	50	1.8	2.3
4 RAY'S SUB SHOP	42	55.	1.8	3.5

JOB: HARRISON/OAK RUN: CASE 1 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60 MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. HARRISON SB FREE	58.	-434	58	566.	1000.	360.	AG	410	24.6	0.0	10.0	0.0	0.0
2. OAK EB FREE	-442	66.	558.	66.	1000	90.	AG	244	24.6	0.0	10.0	0.0	0.0
3. OAK EB Q	49.	67	-17.	65.	66.	269.	AG	716	100.0	0.0	10.0	0.50	10.1

JOB: HARRISON/OAK RUN: CASE 1 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS VET	45	91	1.8	0.8
2. TUFTS UNIV	71	80.	1.8	1.0
3. TAI LOY MARKET	76.	50	1.8	0.8
4. RAY'S SUB SHOP	42.	55.	1.8	1.4

JOB: HARRISON/OAK RUN: CASE 2 8-HOUR

I SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000 M
ALL DEGREES BY 10 Z0 = 321 CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. HARRISON SB FREE	58.	-434	58	566	1000.	360.	AG	388.	24 6	0.0	10.0	0.0	0.0
2. OAK EB FREE	-442.	66.	558.	66	1000.	90.	AG	289.	24 6	0.0	10.0	0.0	0.0
3. OAK EB Q	49.	67.	-17.	65.	66	269.	AG	716.	100.0	0.0	10.0	0 59	10 1

JOB: HARRISON/OAK RUN: CASE 2 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1 TUFTS VET	45	91.	1.8	0 8
2 TUFTS UNIV	71	80	1 8	1 0
3 TAI LOY MARKET	76	50	1 8	0 8
4 RAY'S SUB SHOP	42	55.	1 8	1 5

JOB: HARRISON/OAK RUN: CASE 3 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S CLAS = 4 (D) VS = 0.0 CM/S ATIM = 60. MINUTES MIXH = 1000. M
ALL DEGREES BY 10 Z0 = 321. CM VD = 0.0 CM/S AMB = 0.0 PPM

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. HARRISON SB FREE	58.	-434.	58.	566.	1000.	360	AG	418.	24.6	0.0	10.0	0.0	0.0
2. OAK EB FREE	-442.	66.	558.	66.	1000.	90.	AG	323.	24.6	0.0	10.0	0.0	0.0
3. OAK EB Q	49.	67.	-17.	66.	66.	269.	AG	716.	100.0	0.0	10.0	0.66	10.1

(LINK COORDINATES (M): X1, Y1, X2, Y2)

JOB: HARRISON/OAK RUN: CASE 3 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1. TUFTS VET	45.	91.	1.8	0.8
2. TUFTS UNIV	71.	80	1.8	1.1
3. TAI LOY MARKET	76.	50	1.8	0.8
4. RAY'S SUB SHOP	42.	55	1.8	1.5

(COORDINATES (M): X, Y, Z)

EPA REGION I CAL03 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC.
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: HARRISON/OAK   RUN: CASE 4 8-HOUR

I. SITE VARIABLES

U = 1.6 M/S   CLAS = 4 (D)   VS = 0.0 CM/S   ATIM = 60. MINUTES   MIXH = 1000 M
ALL DEGREES BY 10   Z0 = 321. CM   VD = 0.0 CM/S   AMB = 0.0 PPM

II LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	LINK LENGTH (M)	LINK BRG (DEG)	TYPE	VPH	EF (G/MI)	H (M)	W (M)	V/C	QAVG4
1. HARRISON SB FREE	58	-434	58	566	1000.	360	AG	420.	24.6	0.0	10.0	0.0	0.0
2. OAK EB FREE	-442	66	558.	66	1000.	90.	AG	244.	24.6	0.0	10.0	0.0	0.0
3. OAK EB Q	48	67.	-17.	65	66	269.	AG	716.	100.0	0.0	10.0	0.50	10.1

EPA REGION I CAL03 INTERSECTION MODEL FOR CARBON MONOXIDE
ENHANCEMENTS FOR OVERCAPACITY QUEUING AND STOP SIGN CONTROL ADDED BY TECH ENVIRONMENTAL, INC
CALINE3: CALIFORNIA LINE SOURCE DISPERSION MODEL - SEPTEMBER, 1979 VERSION

JOB: HARRISON/OAK   RUN: CASE 4 8-HOUR

**** MAXIMUM CONCENTRATIONS FOR ALL WIND DIRECTIONS ****

RECEPTOR	X	Y	Z	TOTAL + AMB (PPM)
1 TUFTS VET	45	91.	1.8	0.8
2 TUFTS UNIV	71	80	1.8	1.1
3 TAI LOY MARKET	76	50	1.8	0.8
4 RAY'S SUB SHOP	42	55.	1.8	1.4

TECHNICAL APPENDIX D

NOISE DATA

TECH ENVIRONMENTAL, INC.
FHWA HIGHWAY NOISE PREDICTION MODEL

RECEPTOR # 1

HOURLY LEQ(DBA)	1990 NO-BUILD	1990 BUILD OPT 1	1990 BUILD OPT 2	1990 BUILD OPT 3
0- 1	72.28	72.56	72.38	72.30
1- 2	70.67	70.95	70.77	70.69
2- 3	68.49	68.77	68.60	68.52
3- 4	64.45	64.73	64.56	64.48
4- 5	63.07	63.35	63.17	63.09
5- 6	67.18	67.46	67.29	67.21
6- 7	71.87	72.15	71.97	71.89
7- 8	74.41	74.69	74.51	74.43
8- 9	75.70	75.98	75.80	75.72
9-10	75.43	75.71	75.53	75.45
10-11	74.41	74.69	74.51	74.43
11-12	75.57	75.85	75.68	75.59
12-13	75.78	76.06	75.88	75.80
13-14	75.48	75.76	75.59	75.50
14-15	75.69	75.97	75.80	75.71
15-16	75.97	76.25	76.08	76.00
16-17	76.17	76.45	76.28	76.20
17-18	76.36	76.64	76.46	76.38
18-19	75.70	75.98	75.81	75.72
19-20	75.54	75.82	75.64	75.56
20-21	75.08	75.36	75.18	75.10
21-22	74.45	74.73	74.55	74.47
22-23	75.02	75.30	75.13	75.04
23-24	74.62	74.90	74.72	74.64
24-HOUR LEQ(DBA)	74.34	74.62	74.45	74.37

TECH ENVIRONMENTAL, INC.
FHWA HIGHWAY NOISE PREDICTION MODEL

RECEPTOR # 2

HOURLY LEQ(DBA)	1990 NO-BUILD	1990 BUILD OPT 1	1990 BUILD OPT 2	1990 BUILD OPT 3
0- 1	66.33	66.90	67.65	66.45
1- 2	64.72	65.29	66.04	64.84
2- 3	62.55	63.12	63.86	62.66
3- 4	58.51	59.08	59.82	58.62
4- 5	57.12	57.70	58.44	57.24
5- 6	72.35	72.40	72.47	72.36
6- 7	72.96	73.08	73.25	72.98
7- 8	73.59	73.78	74.04	73.63
8- 9	74.03	74.25	74.57	74.07
9-10	73.93	74.15	74.45	73.97
10-11	73.59	73.78	74.04	73.63
11-12	73.98	74.20	74.51	74.03
12-13	74.06	74.29	74.61	74.10
13-14	73.95	74.17	74.47	73.99
14-15	74.03	74.25	74.57	74.07
15-16	74.13	74.37	74.70	74.18
16-17	74.21	74.45	74.79	74.26
17-18	74.29	74.53	74.88	74.34
18-19	74.03	74.25	74.57	74.08
19-20	73.97	74.19	74.50	74.01
20-21	73.81	74.01	74.30	73.85
21-22	73.60	73.79	74.06	73.64
22-23	73.79	73.99	74.28	73.83
23-24	68.67	69.24	69.99	68.79
24-HOUR LEQ(DBA)	72.74	72.96	73.27	72.78

TECH ENVIRONMENTAL, INC.
FHWA HIGHWAY NOISE PREDICTION MODEL

RECEPTOR # 3

HOURLY LEQ(DBA)	1990 NO-BUILD	1990 BUILD OPT 1	1990 BUILD OPT 2	1990 BUILD OPT 3
0- 1	69.41	69.43	69.43	69.61
1- 2	67.80	67.82	67.82	68.00
2- 3	65.62	65.64	65.65	65.83
3- 4	61.58	61.60	61.61	61.79
4- 5	60.20	60.22	60.22	60.41
5- 6	80.70	80.70	80.70	80.71
6- 7	80.89	80.89	80.89	80.90
7- 8	81.11	81.11	81.11	81.13
8- 9	81.27	81.27	81.27	81.30
9-10	81.23	81.24	81.24	81.26
10-11	81.11	81.11	81.11	81.13
11-12	81.25	81.26	81.26	81.28
12-13	81.28	81.29	81.29	81.31
13-14	81.24	81.24	81.24	81.27
14-15	81.27	81.27	81.27	81.30
15-16	81.31	81.31	81.32	81.34
16-17	81.34	81.35	81.35	81.38
17-18	81.37	81.37	81.38	81.41
18-19	81.27	81.27	81.27	81.30
19-20	81.25	81.25	81.25	81.28
20-21	81.19	81.19	81.19	81.21
21-22	81.11	81.11	81.12	81.14
22-23	81.18	81.18	81.18	81.21
23-24	71.75	71.77	71.77	71.96
24-HOUR LEQ(DBA)	80.01	80.01	80.01	80.04

TECH ENVIRONMENTAL, INC.
FHWA HIGHWAY NOISE PREDICTION MODEL

RECEPTOR # 4

HOURLY LEQ(DBA)	1990 NO-BUILD	1990 BUILD OPT 1	1990 BUILD OPT 2	1990 BUILD OPT 3
0- 1	63.84	64.04	64.18	63 94
1- 2	62.23	62.43	62.57	62 33
2- 3	60.06	60.26	60.39	60.15
3- 4	56.02	56.22	56.35	56.11
4- 5	54.63	54.84	54.97	54.73
5- 6	58.75	58.95	59.08	58.84
6- 7	63.43	63.63	63.77	63 53
7- 8	65.97	66.18	66.31	66.07
8- 9	67.26	67.46	67 60	67 36
9-10	66.99	67.19	67.33	67.09
10-11	65.97	66.18	66.31	66.07
11-12	67.13	67.34	67.47	67.23
12-13	67.34	67.55	67.68	67.44
13-14	67.04	67.25	67.38	67.14
14-15	67.25	67.46	67.59	67.35
15-16	67.54	67.74	67.87	67.63
16-17	67.74	67.94	68.07	67.83
17-18	67.92	68.12	68.26	68.02
18-19	67.27	67.47	67.60	67.36
19-20	67.10	67.31	67.44	67.20
20-21	66.64	66.84	66.98	66.74
21-22	66.01	66.22	66.35	66.11
22-23	66.58	66.79	66.92	66.68
23-24	66.18	66.39	66.52	66.28
24-HOUR LEQ(DBA)	65.91	66.11	66.24	66 00

PARKING NEEDS AND SITE EVALUATION STUDY

New England Medical Center Hospitals
Boston, Massachusetts

Vanasse/Hangen

EXECUTIVE SUMMARY

PARKING NEEDS AND
SITE EVALUATION STUDY

EXECUTIVE SUMMARY

Prepared for

NEW ENGLAND MEDICAL CENTER HOSPITALS, INC.
BOSTON, MASSACHUSETTS

August, 1986

Prepared by

VANASSE/HANGEN
Transportation Engineers & Planners
60 Birmingham Parkway
Boston, MA 02135

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INTRODUCTION

The New England Medical Center Hospitals, Inc. (NEMCH) is a 469-bed referral center and is the primary teaching site of Tufts University, School of Medicine, specializing in the diagnosis and treatment of serious illnesses. The medical center area is located in the South Cove area of Boston, adjacent to Chinatown and the Theater District.

The medical center faces a challenge in ensuring adequate transportation access to its facilities. The vast community of the Medical Center staff, patients and visitors converge daily on a compact urban campus, located in the southeast corner of Boston's downtown. While the campus is fairly well served today by public transportation, the medical center draws large numbers of trips each day from the far reaches of the Boston metropolitan region. The most practical -- and in many instances, the only feasible -- mode of transportation for many of those traveling to the medical center is by automobile.

Recognizing the need for adequate medical center-controlled parking and being sensitive to its location adjacent to the Chinatown community, NEMCH retained Vanasse/Hangen to conduct a study of three alternative parking supply options. The primary purpose of the study is as follows:

> *To evaluate the three alternative parking sites currently under consideration and determine their relative impacts with respect to traffic flow, air quality and noise.*

A further objective of the study was to evaluate parking needs within the context of the medical center's broader transportation requirements. In support of this latter objective, the study incorporated analysis procedures designed to:

- verify the parking space needs of the medical center,

- examine the transportation management measures currently in place at the medical center and evaluate potential improvements in the medical center's transportation management program, and

- develop a plan to mitigate the impact of a new parking facility on the community and surrounding roadway network.

The study process consisted of a series of analysis tasks designed to document background transportation conditions and parking needs, assess the impacts of alternative parking garage sites, and evaluate potential transportation management and mitigation measures.

The study began with an assessment of existing parking and traffic conditions in the study area, which included an extensive data collection effort. Once existing conditions were defined, future parking needs and background traffic conditions were estimated for the planning horizon year of 1990. Hospital growth projections and development plans were reviewed to determine how parking demands will change through the year 1990.

Traffic impacts were then estimated in conjunction with the operation of a new 850-space medical center garage at each of three alternative sites in the study area. Peak period trip generation at the garage was determined and the impacts associated with traffic operations, air quality and noise levels were quantified and evaluated.

A wide range of potential transportation management and traffic mitigation measures were then identified. Included were potential actions to lower the medical center parking requirements, reduce any adverse impacts associated with a new garage, and increase the availability of parking spaces to community residents.

The following paragraphs briefly summarize the findings. For more detailed information, a comprehensive Technical Report has also been prepared.

EXISTING MEDICAL CENTER PARKING SUPPLY

Parking spaces controlled by the medical center are currently utilized in six off-street facilities. Table 1 shows the number of spaces provided for hospital users and the user designation at each facility. The total off-street hospital parking supply, as inventoried by Vanasse/Hangen, is 1,723 spaces. This is somewhat fewer than the medical center's records, primarily due to some currently unusable spaces in the Herald Street garage.

TABLE 1
PARKING SUPPLY

	Supply	User Designation
Posner Lot	193 spaces	Employees, patients and visitors
Herald Street Garage	368 spaces	Employees, students
Tremont Street Garage	930 spaces	Employees, patients and visitors
Oak Street Lot	72 spaces	Employees
Washington Street Lot	60 spaces	Employees (2nd shift)
Shopper's Garage	100 spaces	Employees
Total	1,723 spaces	

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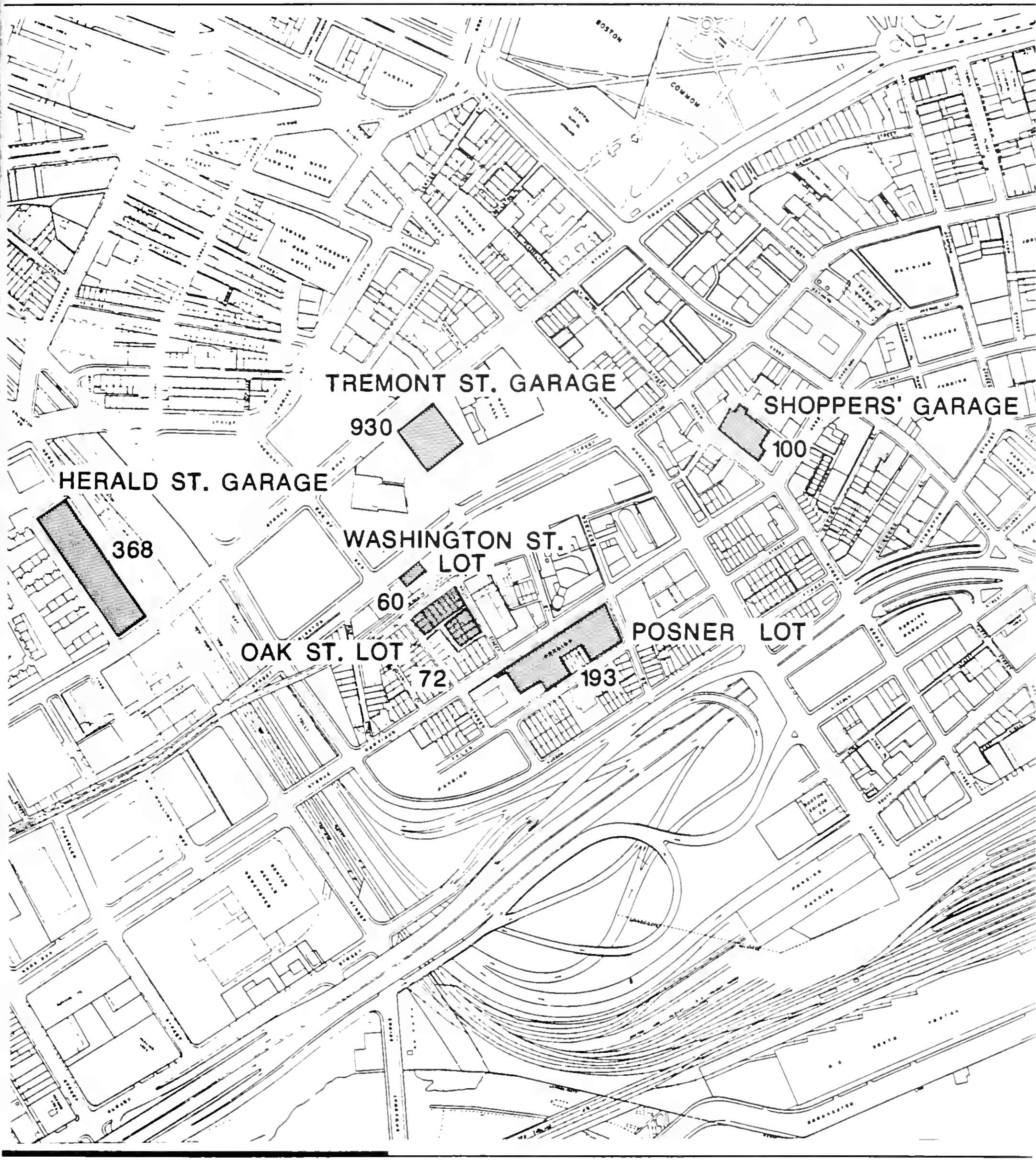
It is important to note that of the medical center's total parking supply, only 1,100 spaces (65 percent) are owned by medical center corporations. The remaining 600 spaces are rented under two to three-year leases and cannot be considered as being available to the medical center on a permanent basis. The facilities owned primarily or completely by the medical center corporations are the Tremont Street Garage, Oak Street Lot, and Posner Lot. The locations of all the medical center off-street parking facilities are shown in Figure 1.

On-street parking is also generally available throughout most of the study area. The major streets which traverse the immediate hospital area provide a total of approximately 210 legal curbside space, most of these being metered. Twenty of these spaces are reserved for resident permit parking only.

To a varying extent, employee parking is provided at all six of the medical center's off-street facilities while patients and visitors park at the Posner Lot and Tremont Street Garage and Tufts students park at the Herald Street Garage. Approximately 550 employees are assigned on a monthly basis to individual hospital-controlled parking facilities. Approximately 500 spaces are also designated for employee use on a daily basis. There is also a fee charged to park on the medical center facilities, ranging from approximately $2.50 for students to $4.00 per day for employees and $.75 per half hour for visitors up to specific maximum charges depending on location.

PARKING DEMAND ANALYSIS

In order to verify the parking needs for the medical center, a parking demand analysis was completed. In general, this consists of both observing and calculating peak parking demands and then comparing them with the parking supply. When conducting



Vanasse/Hangen
Consulting Engineers & Planners
60 Birmingham Parkway, Boston, MA 02135

Off-Street Parking Supply

Fig. 1

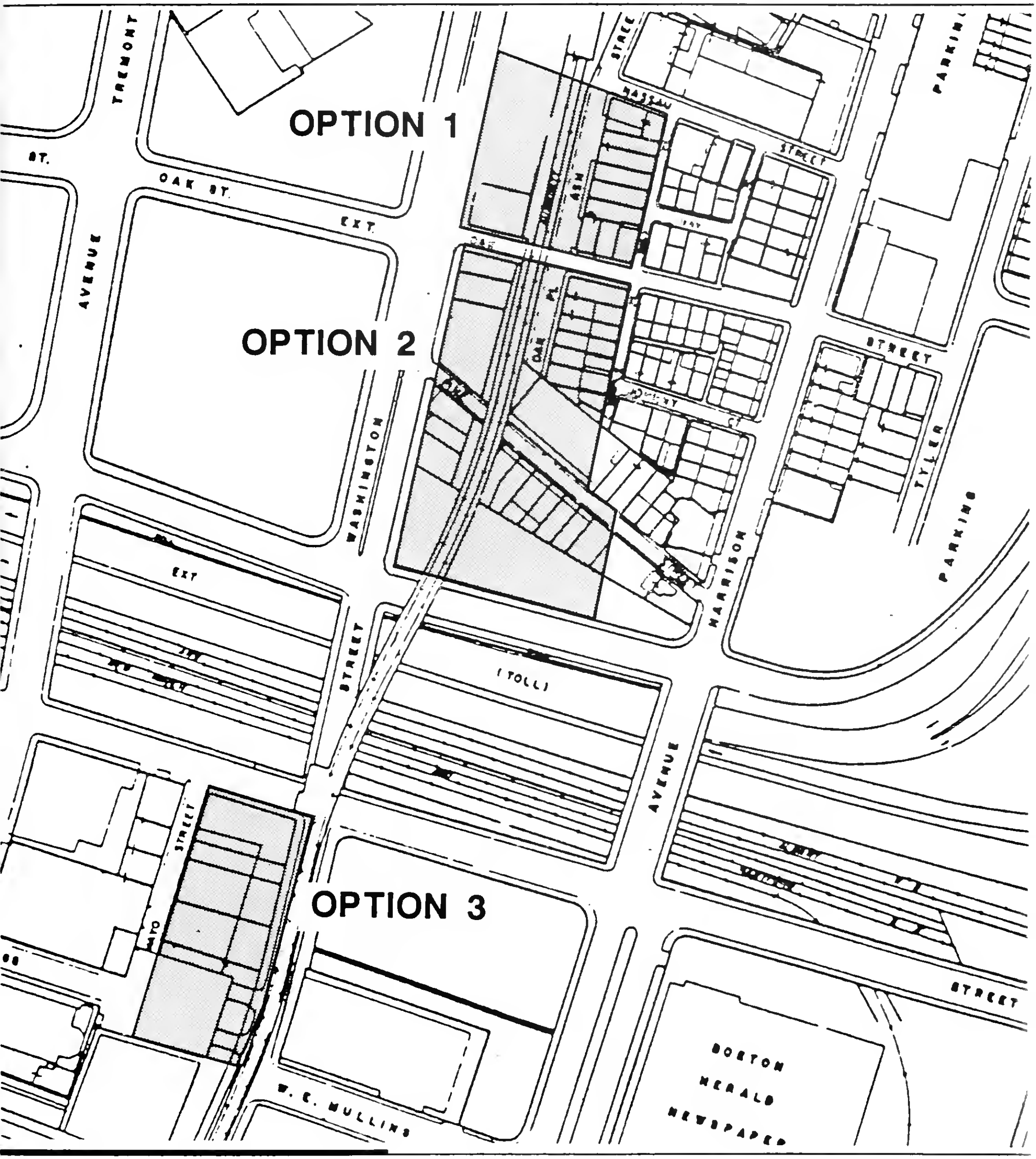
this evaluation, both physical and practical supply are considered. Practical supply, which ranges from 85 to 95 percent of physical capacity, accounts for space efficiency, vehicle turnover, and motorists searching for available spaces. Practical supply is commonly used when determining the desirable number of parking spaces to provide. If a parking facility is to operate efficiently, its occupancy level should be below 100 percent to allow drivers entering the facility to find available spaces without excessive delay or inconvenience. As the occupancy of a parking facility approaches 100 percent, illegal parking and circling or "cruising" within the facility by drivers searching for spaces become more frequent. In the case of the the medical center, the cruising largely takes place on the surrounding street network. Some studies have shown that "cruising" traffic can represent anywhere from 30 to 70 percent of the roadway volume in an urbanized area.

When assessing the parking needs for the medical center, other factors must also be considered including the desirability of hospital related parking occurring on-street and the fact that more than one-third of the medical center's off-street spaces are leased and cannot be considered part of the medical center's permanent supply.

As a result of completing the parking supply/demand analysis, it is clear that a definite need exists for expansion of the medical center's contolled parking supply to as many as 1,069 spaces.

ALTERNATIVE FACILITY SITES

The three alternative garage sites which were selected for evaluation are shown in Figure 2. Site 1, the Nassau Street Site, is located at the corner of Washington and Oak Streets, extending northward to Nassau Street. Although different configurations are being explored by the medical center, this site at a



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60 Birmingham Parkway, Boston MA 02135

Alternative Parking Facility Sites

Fig. 2

minimum is approximately 200 feet by 200 feet. Site 2, the R3/R3A site, is directly to the south of Option 1, across Oak Street. The parcel is bounded by Oak, Washington and Marginal Streets, as well as existing residential buildings on the R3B site. This site has the largest footprint, being approximately 300 feet by 160 feet. Site 3, the SCM building at 50 Herald Street, is over 300 feet to the south of the southern edge of the R3/R3A parcel, across the Massachusetts Turnpike. The site, which has approximate dimensions of 115 feet by 295 feet, is bounded by Herald Street on the north and Washington Street on the east.

Current plans are to construct a 750-space to 850-space facility at whichever of the sites is selected. A conservative or worst case evaluation assumed an 850-space garage. Viewed in terms of scale, all three sites are similar, in that the parking facility must be sized to accommodate 850 spaces. The surface area available at each site does vary, however, and dictates the size of the proposed facility's footprint. Where a smaller footprint is necessitated, the height of the structure must increase. The largest of the three alternative parcels is Site 2, the R3/R3A site, and an above ground five-level structure, roughly 50 feet in height, could accommodate the 850 spaces. Depending on the specific design configuration chosen, an 850-space structure on the Nassau Street site (Site 1) would be approximately 7 levels, or 70 feet in height. The dimensions of the SCM site (Site 3) would dictate that an 850-space structure be 10 levels, or 100 feet above ground level.

EVALUATION OF ALTERNATIVE SITES

The evaluation of the three alternative sites focused on determining the relative impacts or changes in traffic flow, air quality and noise conditions when compared to the 1990 No-Build condition.

In addition to the above, the following areas were examined or identified:

- parking layout efficiency,
- pedestrian accessibility,
- vehicle accessibility, and
- land use.

In assessing the traffic flow, air quality, and noise impacts associated with garage operations at each of the alternative sites, several steps were taken. First, peak hour vehicle-trips into and out of the new parking facility were estimated. In developing traffic flow patterns, the regional distribution of the medical center-related trip origins was determined, and trips to and from the medical center were assigned to the regional and local study area highway network, based on access conditions (i.e., circulation system, travel time) between the medical center and individual points of origin/destination. Details on this process are described in the Technical Report.

Traffic Analysis Summary

The assessment of the traffic impacts associated with three alternative parking garage (850 spaces) sites was completed, in terms of changes in traffic volumes, traffic flow and quality of vehicle access and is briefly summarized below. Overall, changes in traffic volumes under any of the site options will not change the fundamental character of any streets in the project area.

- Site 1 (Nassau Site)

This site offers a generally favorable location with respect to space layout and internal circulation. At minimum, the site is approximately 200 feet by 200 feet with latest concepts resulting in a longer more efficient facility. Located in the

heart of the medical center, pedestrian accessibility would be excellent for garage users. In general, vehicle access to and from the site would also be good assuming a median break on Washington Street. Currently the site, which is partially used as a small surface parking lot, is planned for some institutional related use as it is within the medical center's designated development area.

It is estimated that the traffic flow impact resulting from a garage located on the Nassau Street site would be concentrated on Washington Street. Current planning includes the actual garage entry/exit points to be on Nassau Street which, however, would be accessed from Washington Street. Based on the analysis of travel patterns and street network, it is estimated that 76 percent of the traffic would be oriented towards the Expressway/ Massachusetts Turnpike and using either Kneeland or Herald Streets to access the facility. Being located between Kneeland and Oak Streets, it is anticipated that the Washington and Kneeland Street intersection would be the most affected intersection in terms of motorist's operating conditions as a result of constructing a garage on Site 1. However, the intersection without further mitigating measures will operate at acceptable levels during the peak travel hours as the increase in congestion ranges from 8 to 12 percent depending on the travel period. In general, all other intersections in the study area are anticipated to operate at satisfactory levels under 1990 peak hour conditions if Site 1 is used for the parking garage.

Traffic volume increases are anticipated to occur on several roadways in addition to Washington Street with Kneeland Street experiencing the largest increases ranging from 80 to 108 vehicles during the peak travel hour. Herald Street peak hour volume increases are expected to range from 51 to 67 vehicles. During the morning travel period when most employees using the new gar-

age will arrive, it is anticipated that a minimal amount of parkers would access the site via the neighborhood streets such as Hudson and Oak Streets and Harrison Avenue. However, without traffic management mitigation measures there is the potential that garage related traffic would divert to local streets, particularly Hudson Street, to access the site during the morning peak hour. Conservatively, it is estimated that approximately 50 vehicles in the peak hour could potentially be diverted. Again, by installing certain traffic management action, this diversion can be substantially reduced or eliminated.

- Site 2 (R3/R3A)

The site, which generally has the largest land area of the three alternatives, offers the opportunity for an efficient parking structure design. Pedestrian access to and from a parking facility constructed on this site to the buildings that makeup the medical center is good, although Oak Street now must be crossed by the pedestrian as opposed to Site 1 where the Site is essentially adjacent to the buildings. With a median break on Washington Street, overall vehicle access/egress is good. The site, which is closer to the neighborhood, is currently planned for residential uses by the Boston Redevelopment Authority. Building a parking facility on this site, therefore, would require modifying current plans.

As a result of the analysis, it has been estimated that of the three alternatives,the R3/R3A would have the greatest impact in terms of traffic volume changes on local streets. It's location between Oak Street and Marginal Street will encourage facility users to divert to the neighborhood streets when accessing the site. In addition, when leaving the facility during the evening peak hour, the greater use of Oak Street and Harrison Avenue would also be expected.

In terms of vehicle operating conditions on the study area roadways, no significant changes from the no-build condition are projected and all intersections are anticipated to operate at satisfactory levels. Although it is estimated that more garage related flow will occur on lower Washington Street (south of Oak Street) and on neighborhood streets under Alternative 2, the intersections affected have ample capacity available to accommodate the increases with a minimal effect on operating conditions.

- Site 3 (SCM Site)

This site, located south of Herald Street adjacent to Washington Street, is a relatively narrow site which would substantially affect the design of the facility. The layout of parking spaces would be less than desirable in terms of vehicle maneuvering and internal circulation would be below average as ten levels would be required to provide 850 spaces. Pedestrian accessibility to this site is also less than desirable as parkers destined for the main activity area of the medical center would have to walk significantly further than under either Alternative Sites 1 or 2. A major street crossing of Herald Street is also required. In terms of overall vehicle access, the site offers the potential for good regional access. However, local access is fair due to the circuitous manner in which parkers would have to proceed in reaching the garage access point. Washington Street is a one-way northbound street adjacent to the SCM site. Also, the analysis indicated that vehicle operating conditions on Herald Street during the morning peak hour could potentially divert facility users through the neighborhood streets (Hudson Street and Harrison Avenue) during the morning peak hour. The site currently contains a one story brick building and is owned by the Chinese Benevolent Association. In addition, the elevated

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Orange Line is immediately adjacent to the site, which in the short term, would effect both construction of the facility and access/egress conditions.

With Site 3, which is farther from the residential areas north of the Turnpike, traffic increases on neighborhood streets would tend to be minimal, since garage traffic would essentially be confined to Herald, Marginal and Washington Streets. However, as stated earlier, depending on operating conditions of the regional system and the level of congestion at the Herald Street/Harrison Avenue intersection during the morning peak hour, motorists entering the facility to/from the north and west could divert to the more local streets, specifically Hudson Street and Harrison Avenue. If this occurs, approximately 30 to 40 vehicles could be diverted.

It is estimated that a parking facility on Site 3 will result in relatively substantial operational impacts on Herald Street traffic flow. During the AM peak hour, overall operating conditions at the Herald/ Harrison intersection would remain acceptable, however, the motorists turning left from Herald Street to Harrison Avenue would experience very long delays causing queues back towards Albany Street. During the PM peak hour, overall intersection operating conditions will decline from acceptable to unacceptable at this intersection. While the intersection of Herald and Washington Streets is projected to operate at acceptable levels,conditions at the Herald Street intersection with Harrison Avenue could affect this condition. In addition, if an MBTA Orange Line replacement service is routed along Washington Street through the Herald Street intersection, as appears probable, traffic operations at the intersection will likely be further impaired.

Air Quality

The objective of the Air Quality analysis is to determine if the proposed new parking facility for the medical center will interfere with the attainment or maintenance of Massachusetts and National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO). Comparison of projected pollutant levels to the NAAQS permits evaluation of whether motor vehicle emissions related to the proposed parking facility will pose a threat to public health or welfare. The two standards set by the Environmental Protection Agency (EPA) are for 1 hour and 8 hour durations.

Comparing the 1990 air quality projections under each site alternative with the No-Build condition show that the proposed garage will increase CO concentrations due to additional roadway traffic and garage emissions. However, the standards or maximum 1-hour and 8-hour CO levels nevertheless will remain in compliance with the NAAQS for Sites 1, 2 and 3. The analysis results, which are detailed in the study's Technical Report, showed that a Site 3 facility increases peak hour CO concentrations the greatest at the location where they are already high, namely the Washington Street and Herald Street intersection. Of the three alternatives, the highest CO levels occur under the SCM site option.

Based on the analysis results, the Nassau Street Site (Site 1) is preferable to both Sites 2 and 3 in terms of air pollution impacts. For all three sites, measures to mitigate air quality impacts would parallel those for traffic impacts, namely those that reduce peak hour volumes, delay times, and increase roadway capacity either through geometry and signalization improvements or demand reduction strategies.

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Noise

The noise environment of an urban community results from numerous sources. Major contributors are vehicular traffic, aircraft overflight, and industrial operations.

The principal objective of this noise impact analysis was to quantify the effects of increased motor vehicle activity associated with the proposed the medical center parking garage on sensitive receptors in the community. To accomplish this, ambient monitoring was performed to establish existing noise levels, and future noise levels were modeled at four representative receptors. The estimated increase in future noise levels can be compared to audible change criteria, while the total traffic noise level can be compared to U.S. Environmental Protection Agency (EPA) noise guidelines.

The City of Boston has regulations for the control of noise. they do not, however, apply to "the operation of any motor vehicle public way, nor to the noise produced thereby."[1] Since the proposed parking garage will only generate noise through the operation of motor vehicles, the City's regulations do not apply.

In the project area, current ambient noise levels are dominated by vehicular traffic and the MBTA elevated orange line and are highest along Washington Street, particularly near the Massachusetts Turnpike, and are significantly lower along Harrison Avenue. This will change once the relocated Orange Line project is completed in 1987.

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1/ Air Pollution Control Commission, City of Boston, "Regulations for the Control of Noise in the City of Boston," Section 2.1(c).

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The noise analysis indicated that a garage facility located on the R3/R3A site (Site 2) would result in a change in noise levels which would be perceptible. The analysis also showed that noise level changes for garages located at Sites 1 and 3 will not be perceptible.

POTENTIAL MITIGATION MEASURES

As part of this study, a series of potential mitigation measures have been identified and evaluated for their respective effects on reducing the traffic related impact associated with the proposed garage facility. The measures studied include both demand management and traffic management elements. Under traffic management, areas including access/egress, neighborhood street management, and traffic flow improvements were identified.

The different actions studied are summarized below:

Demand Management

- Ridesharing
- MBTA monthly pass distribution
- MBTA monthly pass subsidy
- Increase employee parking fee
- Shuttle Bus - South Station

Traffic Management

- Access/egress control equipment
- Access/Egress lane capacity
- Close Nassau Street as through street
- Prohibit left turns onto Hudson Street during AM peak
- Prohibit left turns onto Oak Street during PM peak
- Signal timing modifications
- Reassign staff from Posner lot
- Close Harvard Street

- Modify one-way flow system (Tyler & Hudson)
- Improve directional signing
- Increase information dissemination
- Restrict on-street parking at intersections

The objective to implementing any or a combination of these actions is to potentially reduce the parking demand currently associated with the medical center and encourage garage related traffic to remain on the major arterial system, thereby minimizing the effect on the neighborhood. Some of the actions are presently being done by the medical center. Parking rates have recently been increased. The proper design of the new facility will ensure adequate access/egress. With the garage being an employee facility, good parking management practices should ensure efficient access during the morning peak hours minimizing the effect on the major arterials such as queuing on Washington Street. Some actions such as restricting parking, modifying signal timing, closing street and turn prohibitions will need the concurrence of the City of Boston.

CONCLUSION

In concluding, this analysis has included a fairly detailed assessment of three alternative parking garage facility sites to be used for the medical center employees. These included sites on Nassau Street (Site 1), the R3/R3A parcel (Site 2) and the SCM site (Site 3). The analysis, which focused on the AM and PM peak travel hours, indicated that on an overall basis, Site 1 is preferable to the other two alternatives. Traffic flow impacts for using Site 1 are relatively minimal on the adjacent roadway system. Although increases in volumes on neighborhood streets will be experienced, certain mitigation measures can be taken to

reduce that impact and encourage garage related traffic to remain on the major arterials and not on residential roadways. Air quality and noise related impacts are also less under Site 1 than the alternative sites. A facility on Site 2 would tend to impact the neighborhood to a greater degree than both Sites 1 and 3 in terms of traffic flow, air quality as well as noise impacts. The effect of building a parking facility on Site 3, which may prove infeasible if, not impractical due to design constraints, will be a relatively substantial impact on the traffic operations along Herald Street. This could in turn divert additional traffic through the neighborhood as motorists access the site, although the magnitude of diverted traffic is difficult to predict.

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